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The Institute of Vitreous Enamellers
The Welsh Engineers' and Founders' Association
The Foundry Trades' Equipment and Supplies Association

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Specifications and Recommended Methods

It is obvious from a discussion which took place one evening last week, at a meeting of the London Section of the Institute of Vitreous Enamellers, that the whole position of recommended methods and specifications is not invariably appreciated. Whilst the members themselves no doubt well understand the difference, certain of them expressed a fear that commercial interests do not. To get a clear conception of what at least a British Standard Specification means, it is essential to realise that there are at least three parties to satisfy before its final adoption. These are the manufacturers, the users, and the general public. The normal procedure is for the British Standards Institution to be approached by an interested party for the issue of a specification related to some process or product. If it be thought that the matter is in the public interest, then a committee is formed representing as many interests as reasonably possible.

The urge for a specification may arise from a number of different considerations and be brought at the instance of the user or the manufacturer. Generally speaking, the party which is best informed as to the real fundamental position of the product or process is the one which finally has its ideas adopted. If it be a question of a range of dimensions, then the views of the merchants carry the more weight, but if it relates to the specifying of acceptance conditions, probably the views of the manufacturer will predominate. This is because his views are based on research work and ascertained data, usually much greater in quantity than the merchant or user. Any industry ever envisaging the future prospect of an acceptance specification is wise to arm itself with "recommended methods," as these supply angles of approach favourable to the manufacturer. Moreover, by effecting co-operative research work for the production of "recommended methods," knowledge of a fundamental character is being acquired, so that when, if ever, the time arrives for creating a specification, the manufacturers are well armed against the imposition of impossible or difficult clauses.

This meeting expressed doubts as to the wisdom of publishing "recommended methods" on the grounds that the purport would be misunderstood, presumably for a specification by the buyers. It is obvious that no matter when publication is effected, conditions would not alter. It is the duty of manufacturers to point out that "recommended methods" are for use inside the industry. They have been established tentatively with the object of creating a vocabulary—that is, to ensure that each member of the industry is talking the same language. We can imagine that when the first attempts were made to establish unified methods of testing cast iron and steel, the same cry would be heard—"a rod is being created for our backs," but it was in the interests of the manufacturers that the methods of testing should be of the same type for each individual works, in order that confusion could be avoided.

Not to come out in the open initially gives rise to unofficial leakage, followed by suspicion. If the present system—a series of "recommended methods," first tentative and then after a period of experimenting adopted, later to be followed by a tentative specification, and finally a B.S. Specification—be followed, nothing but good can result. Moreover, the carrying out of such work by an industry is productive of much good on the following grounds:—

(1) Opportunities are provided for the technicians of the industry to exchange views on matters concerning the industry as a whole.

(2) Vague expressions, such as good, high, excellent, etc., are replaced by understandable figures.

(3) Research tending towards the attainment of better results is set in motion.

(4) Systems of internal control are reinforced.

(5) Armour for defence against the imposition of buyers' private specifications is forged.

From the above it is evident that no progressive industry can neglect to progress along the lines indicated, and any temporary inconveniences arising from mistaken application by users must be ignored or fought by reason.

D

Lancashire Foundrymen in Session

A meeting of the Lancashire Branch of the Institute of British Foundrymen was held at the Engineers' Club, Manchester, on Saturday, November 4, Mr. A. L. Key (the Branch-President) in the chair.

R. A. Jones Medal Award

MR. H. V. GRUNDY recalled that the immediate Past-President, Mr. R. A. Jones, had made provision for the presentation of a medal for the specific purpose of encouraging all classes of members to contribute to discussions upon the various Papers. This medal was called the R. A. Jones Merit Award. The Committee had come to the unanimous conclusion that Mr. Arthur Phillips had earned the award during the previous session. Mr. Grundy had great pleasure in tendering to Mr. Phillips the congratulations of the Committee, and also his own, upon the success he had achieved. The medal was not quite completed as yet, because it lacked the necessary inscription, but it was hoped to be able to present it to Mr. Phillips at the next meeting of the Branch.

The BRANCH-PRESIDENT announced that the Committee which had judicated upon the award consisted of the donor, Mr. R. A. Jones, Mr. T. Makemson, the General Secretary of the Institute, the Branch-President, and the Branch-Secretary, together with two elected members from the general body of members. The two members elected previously had been Mr. R. N. Wallwork and Mr. S. Tongue. Unfortunately, they had lost a good member in Mr. Wallwork, who was now deceased, and Mr. Phillips was asked to join the Committee.

MR. GRUNDY mentioned that the Committee were of the opinion that the amount of discussion which had taken place upon Papers during the past year was somewhat disappointing. It was found that practically all the discussion was due to the efforts of about three members. Mr. R. A. Jones had made a very generous gift to the Branch and the medal was obviously well worth winning. At the same time, the medal itself was not the sole object to be considered regarding the discussions. What was desired was that discussions should be much more general or widespread than they had been of recent years, and that more members would be encouraged to speak. In mentioning this point he did not wish to detract in any way from the merit of Mr. Phillips in winning the medal. That gentleman was always ready to contribute to the discussion.

A General Discussion

The PRESIDENT mentioned that Mr. John Cameron, jun., who had promised to read a Paper that afternoon, was now engaged upon military service. Owing to the difficulty of obtaining lecturers at short notice, it had been decided that the afternoon should be devoted to a discussion of foundry problems generally. Three members had come forward with subjects for discussion, namely, Mr. A. Sutcliffe (Bolton), Mr. A. Jackson (Accrington) and Mr. R. Yeoman (Loughborough), the last-named gentleman having offered his services at 12 hours' notice.

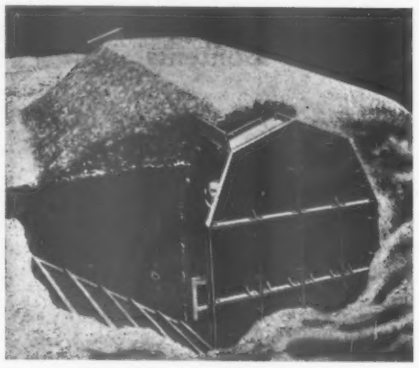
Supplementing the remarks of Mr. Grundy, the Branch-President expressed the hope that some of the members would speak who were not usually articulate at the meetings. It was quite certain, he said, that they all had something important, and it was definitely the wish of the older members that discussions should not be confined to a few people.

The discussion which then ensued will be reported in the JOURNAL next week.

Unit-Construction of Cast-Iron Air-Raid Shelters

Amongst the vital factors in air-raid shelter design are speed and ease of erection and adaptability of the shelter to give protection to additional numbers of people as the necessity arises. These advantages are assured by the adoption of the unit-construction principle.

The F.S.50 type, which is manufactured and marketed by Federated Sales, Limited, 80, Grosvenor Street, London, W.1, is constructed of cast-iron units bolted together to make a complete shelter, approximately 42 ft. 6 in. long by 5 ft. wide, with a head room of 6 ft. 6 in. No skilled labour is required, and the trench can be dug by the firm's own work-people, and, as



F.S.50 TYPE OF CAST-IRON AIR-RAID SHELTER.

the earth excavated is sufficient on top, no additional material is needed. Erection, it is claimed, can be carried out by unskilled labour in a third of the time taken to build a concrete shelter of similar capacity.

All parts are ready for immediate erection without machining, and the shelter can be dismantled and the site made good in quick time, the metal having a considerable after-war recoverable value.

The F.S.50 shelter complies with Home Office regulations, and is subject merely to local Officer's approval. It has been "high-explosive" tested under Home Office Authority. The shelter should make an immediate appeal to those concerns who have had to delay their air-raid precaution plans, the more so as this type is available for immediate delivery.

Electric Motor Drives

Dr. P. F. Strizl, in a Paper which he has presented to the Manchester Association of Engineers dealing with electric motor drives, has summarised his conclusions in the following terms:—

(1) The motor itself is only one component of a drive and should not be considered alone; only a planned co-ordination of motor and control gear, of mechanical and electrical considerations, with the addition of suitable protective gear can result in the production of a drive permitting the best possible use to be made of the driven machine.

(2) It is essential that not only the required power and speed, but the fullest possible particulars of the construction and working process of the driven machinery be made known to the makers of the electric equipment, so as to obtain the full benefit of all the means at the disposal of the designer, and at the same time to avoid the waste which the selection of unnecessarily large or complicated equipment would entail. It is also advisable to avoid imposing restrictions as to temperature rise, etc., as the manufacturers of electric equipments know best what stresses, in the widest sense of the word, they may expect of their gear.

Random Shots

Mr. "Dash," father of a Trooper in the Duke of Lancaster's Yeomanry and a "commissioned officer" in the Institute of British Foundrymen, had just said goodbye to his son at a station "somewhere in England." Walking down the platform he overheard the following conversation between two Cockneys.

"Did yer see that bloke wiv the chines on 'is shoulders and D.O.L.? Wot's 'is regiment, Bill?" "Don't rightly know, 'Arry," replied his mate, "but it ain't the Durham Light 'Orse!"

* * *

An extract from an article headed "Drink in wartime" reads as follows: ". . . . and several of the changes made nuder the Defence of the Realm Act . . . ." Was Dora's reputation for being a straight-laced old maid all wrong then, or is there another "apology impending"?

* * *

Mr. X was already gaining a reputation as a loser of his gas mask, which had spent the night in more than one lost-property office and on the hat peg in more offices than any other gas mask in London. Mr. X was beginning to be ashamed of his carelessness and so, when he attended a committee meeting in Birmingham, he was determined that he would not leave it behind. Many were the opportunities, but he successfully picked it up from the committee room table, remembered to take it away with him from the hotel at which he lunched, and even rescued it at the last moment from the train. Feeling very pleased with his success, he walked triumphantly in at the front door of his home swinging it to and fro significantly.

"You see, my dear," he said, "I have remembered to bring home my gas mask to-day. Very clever, I call that!" "Very clever," retorted his wife, "especially when your gas mask is here on the hallstand. You forgot to take it this morning!"

* * *

That Christmas is approaching is evident, for each morning the postman is bringing what might be termed the first of the Christmas mail. They get their innings in early, these charity appeals, with their yawning, gaping envelopes, and their lean and empty canvas stockings. They want you not to forget them, quick, before the Christmas catalogues come along to tempt even the most thrifty soul, and well before the I.T.D. (income tax demand) begins to loom dangerously near, threatening to shatter completely that already weakly-looking balance at the bank! Each one hopes that you will "give generously," for that is the invariable slogan of all such appeals. It is not very funny when one would like to give handsomely but has not the wherewithal, but on one occasion that appeal had an unexpected touch of humour about it. It was a special appeal for the London hospitals and every hospital had the chosen slogan displayed on a large board outside the building. This time "give generously" was superseded by the injunction to go one better and "give till it hurts."

* * *

A youngster who had been learning at school something of life in the days of crusaders and troubadours, wants to know if a modern soldier who sings as he marches is called a troopadour?

* * *

Out of the Mouths of Babes!

"I do so hate wars. You're always having to touch so much wood."

"What on earth for?" asked a thick-skulled parent.

"Well, there's so little you can be certain of in wartime."

"MARKSMAN."

The Cupola and the Melting of Iron

COMMENTS ON PROF. GIRARDET'S VIEWS

By H. H. SHEPHERD (Chief Metallurgist, Crane, Limited)

Prof. L. F. Girardet's Paper on "The Cupola and the Melting of Iron," extracts from which appeared in the JOURNAL for November 2, gives very valuable, interesting and most refreshing views on the melting of iron in the cupola. It is felt, however, that there are a number of points which others—like the writer of these notes—will query, though it is also felt that most of the views or theories of Prof. Girardet are in full agreement with those of other authorities and the unique way in which some of the theories and practices are enlarged upon more than counterbalances the points of disagreement.

Some of the paragraphs are, in the commentator's view, well worth repeating, as for example, the following:—

"If the size of coke be changed the depth of the zone is also changed . . . An iron rich in silicon and manganese will heat up itself by increasing the period of oxidation (lengthening of the path), another low in these elements will lose (especially) iron: will be cold and sticky. *It must not be lost sight of that in the first case the situation has been saved by the burning of the silicon and manganese, which, as fuel, are much more expensive than coke.*" (Mr. Shepherd's italics.)

"Hence the necessity of thorough understanding of what happens in the cupola and the relation between what goes on in, and what comes out, so as better to control the cost price."

The four principles which are given as governing cupola operation are in general, of course, well known, though the importance of the fourth might be stressed, even if only considered from the point of view of checking up the accuracy or inaccuracy of throat or exit gas analyses, because we are all aware that many figures which are given as representing throat gas compositions cannot be accepted without question.

The Deville Principle

With regard to the first of the four principles given, it seems to the present writer unusual, even if there were justification in the Professor's particular practice, to describe the zone of maximum temperature by an empirical "rule" based on results published so far back as 1857, when there is a much more scientific explanation and definition of this maximum temperature zone area; this is, of course, that of A. W. Belden.

The result of Belden's investigations clearly showed that the highest temperature area was in the shape of an inverted cone, with the base intersecting the cupola lining at a point about 20 in. above the top of the tuyères. It is of course clearly understood that the exact location of this zone—which is indicated by the area A, B, C in Fig. 1, will depend on the pressure, velocity of gases and the volume of air supplied to the cupola.

Belden's findings have been accepted and corroborated by practically all other investigators, including such well-known authorities as J. E. Fletcher, Campbell and Grennan (U.S.A.), Mathesius (Germany), etc. Therefore, whilst the "rule"—"That the zone carrying maximum temperature is that situated above the tuyeres extending vertically ten times the average diameter of the pieces of fuel"—might well be applicable to a particular cupola practice using a particular average size of coke, one surely cannot accept this finding as a "rule" in the strict sense of the word, because it does not appear to fit in with universal practice. It can easily be visualised that if this were so there are many cases where the *maximum* temperature zone would extend for 4 to 5 ft. or more when the average diameter of the pieces of coke was 5 to 6 in.

The commentator would hasten to add that he does not belittle the findings of Deville because they date back to 1857, but the repeated reference to them by Prof. Girardet throughout his article is perhaps disappointing in view of the availability of more fundamental evidence and the fact that coke size varies so considerably that the writer feels dubious about the present-day acceptance of Deville's work.

On the other hand Prof. Girardet may have more information at his disposal to support his

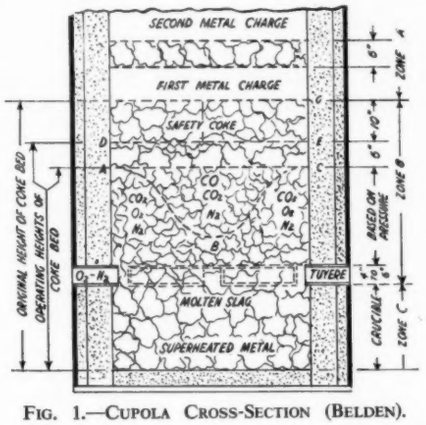


FIG. 1.—CUPOLA CROSS-SECTION (BELDEN).

confidence in Deville's "rule." If so, it is felt that readers of THE FOUNDRY TRADE JOURNAL would appreciate the Professor placing these details at their disposal.

Exit Gases

With regard to principle No. 2, it is recognised that in order to avoid oxidation the height of the coke bed, velocity and volume of air must be such that all melting takes place above the level represented by the line AC.

The presence of appreciable oxygen in the exit gas at near the charging-door height indicates poor practice, resulting in oxidised metal, lacking fluidity. On the other hand, excess of carbon monoxide in the exit gases will retard the melting and prevent the attaining of maximum superheat due to the fact that heat is absorbed in reaction between the CO_2 and carbon of the coke, which is a point brought out by the third principle referred to in the Paper.

The Coke Bed

"The Story of the Coke Bed" is most interesting and points out some facts which those who are in contact with cupola melting from day to day are inclined to ignore through familiarity. The description of the movement of the charges downward during tapping "as of the column of materials rested on a raft set upon liquid iron" will, the commentator feels sure, fix itself permanently and clearly in the mind of every cupola executive who reads it.

With regard to the views of the author of the Paper on the question of autopurification, reference is made to "deoxidising," which brings to the mind of the commentator a query which he has a habit of putting up to all "deoxidationists," namely: Is maximum deoxidation advisable? His personal view is in the negative, though this does not mean that he favours running a cupola under anything approaching severe oxidation conditions. This point is merely raised as a matter of interest, and it is not intended as a criticism or counter-remark to Prof. Girardet's views on the subject.

Carbon Pick-up

Reference is now made to the words which read: "Generally speaking, carburisation in the crucible becomes the principal complaint." The present writer cannot entirely agree with this, because contrary views and evidence have been given by investigators, among them being Mackenzie, Johnson, Parkes and Bamford. These investigators state that there is no material increase in carbon content of metal left in the well of the cupola, and that the greatest amount of carbon pick-up occurs in the melting zone.

On the other hand, Sipp and Tobias support Piwowarsky and Ackenbach, who hold the more common view that the retention of iron in the well of the cupola increased the carbon content. There are, however, some main factors which are indisputably held as affecting the carbon pick-up, such as:—

(1) The type and composition of the mixture. In this connection the carbon content of the mixture is a prime influence.
(2) Reactivity and size of coke.
(3) Height of coke bed.
(4) Variation in coke-bed height.
(5) Temperature of melting zone.
(6) Air volume and pressure.

The higher the temperature the greater the carbon absorption; hence, other factors being equal, the higher the melting zone temperature the higher the carbon pick-up.

Coke Reactivity

As regards reactivity of coke, it is generally accepted that dense coke having low reactivity gives lower carbon absorption than the light, open cokes of high reactivity.

Mackenzie showed that low tuyères tended to give high carburisation and *vice-versa*; that intermittent taps gave higher carbon than continuous taps, though here again it was found that this effect was more permanent for low-situated tuyères than high. It might be felt, therefore, in view of Mackenzie's work, that retention of molten iron in the well resulted in higher carbon absorption, but the investigator claimed that the increase in carbon absorption was negligible in most cases.

To sum up, the commentator's view with regard to carbon absorption in the well is that there appears to be equal evidence for and against carbon pick-up in this part of the cupola, and it is therefore felt that the matter should be further investigated, but the opinion is expressed that Mackenzie is nearer to the true explanation when he says that much depends on the method of operation, and whether due to slagging conditions iron can come into contact with clean coke or not. To this must, however, be added the all-important influence of the actual carbon content of the mixture.

Decarburisation

One of the most interesting views put forward by Prof. Girardet is that with regard to decarburisation, which is linked up with the statement that the pieces of iron only start to melt from the *outside* where they are free from gas action. The author expresses the view that the result of gas action will be to decarburise the skin so that this becomes less fusible, and therefore melting proceeds from the inside of the pieces which carry a higher carbon content. Particular attention is drawn to the extremely interesting way in which Prof. Girardet confirmed his views in connection with this.

Finally, with regard to the melting of steel, the Paper states that the steel is not cemented or carburised in the solid state by the gases or contact with coke, though actual drops of liquid iron falling on to the steel might result in local

carburisation. General carburisation is claimed to take place as the result of contact of the molten steel with coke.

These claims are confirmed by Piwowarsky and Ackenbach,* and have been generally accepted by other authorities, who agree with the views that have been expressed, that carburisation cannot be effected in the solid state by contact with the gases, and for the reason set out in the Paper, "because the time factor is insufficient and the contact is pretty poor," there is no carburisation of the *solid* steel by coke.

Heat Losses in the Receiver

With regard to the loss of temperature by iron stored in the crucible or well of the cupola, Prof. Girardet expressed the view that this loss is greater than where a receiver is used, but the commentator would suggest that this view needs confirmation by the publication of more details. Though the author qualified his claim by stating "from a purely physical point of view," the writer would suggest that general *practical* experience makes it rather difficult to accept the unusual view, even taking into account the points which are put forward in favour of it, namely, less surface due to the absence of coke.

The well-known practice over a large number of years with regard to the use of receivers is that if one requires to minimise the loss of temperature arising from storage in the average type of receiver, it is necessary to apply auxiliary heating such as oil-firing, and even with the modern type of these pieces of equipment or storage ladles, which incorporate correctly-designed heat insulation, there is some drop in temperature, although it is admitted that the major loss, as in the case of storage or bull ladles, arises from the transfer of the metal from the cupola to the ladle, and personal practical experience is that in the event of a foundry breakdown—when it is necessary to hold the metal—it is far better to retain it in the well of the cupola and not in the storage ladle, which is incidentally one of the latest types suitably insulated. This has been proved a number of times.

That there are exceptions to the above practices is not disputed, as for example when the brick lining of the well of the cupola is comparatively thin, either through design or wear. The view is expressed that the type and thickness of the well lining have a much greater influence on loss by radiation than that which can be related to surface area or to the presence or absence of coke.

Finally, the commentator would again remark that Prof. Girardet approached the subject of cupola melting in a very refreshing and perhaps unique manner. His article reveals once again that the cupola is still capable of intensive study, and foundrymen may even yet see some material change in the practice of melting iron, which has not materially altered for about 200 years.

In this connection, the writer might mention the amazing new principle which has recently been voiced in connection with cupola melting. This is brought forward by a German worker who claims that the best possible utilisation of heat of the coke in the cupola should be by radiation rather than by convection, and he claims to have discovered a new method whereby melting is carried out through radiated heat from a coke layer on the top of the charge. In this case, however, the charging of the furnace is said to be intermittent so that each charge is melted individually. This may react against the valuable feature which the cupola has always possessed over many other melting furnaces, that is, continuous melting, but no doubt more will be heard about this new process through these columns at a later date.

* "The Melting of Steel Scrap in the Cupola," "Die Giesserei," February 25, 1938.

Founders' Forum

Q.—Why is zinc beneficial?

A.—One reason for the beneficial effects of zinc appears to be connected with the question of gas absorption. It is known, for example, that 70/30 brass is relatively immune to hydrogen unsoundness. R. Genders and G. L. Bailey have shown that the soundness of sand-cast 70/30 brass melted in an atmosphere of hydrogen was unaffected, whilst a 5 per cent. tin-bronze treated under similar conditions showed 150 per cent. increase in porosity. It is suggested that the factor responsible for this exceptional behaviour of 70/30 brass is the high vapour pressure of the molten alloy. Analogy may be made with solution of gas in water whereby the solubility of a gas (providing it does not react chemically) decreases with increasing vapour pressure of the water, becoming zero at the boiling point. It would appear probable that the solubility of chemically inert gases in brass decreases in a similar manner as the partial pressure of the zinc approaches atmospheric pressure, becoming zero at the boiling point. The atmosphere above the molten brass in the crucible consists of evolved zinc vapour, and the partial pressure of any soluble gases is accordingly lowered, so that they are automatically expelled from the metal. The effect of zinc in removing gases from bronzes may act along similar lines, although to a much less degree. It is important to note that the evolution of zinc vapour must take place in order to effect gas removal. A further beneficial effect of zinc addition to bronze is that this prevents excessive oxidation of tin. In the melting of bronze from virgin metals under oxidising conditions it may happen that the copper becomes over-oxidised, with the result that when the tin is added, tin oxide is formed in the metal. This oxide has a high hardness, and is particularly detrimental in bronzes required for bearing purposes. So long as the copper contains zinc, tin oxide cannot form, due to the preferential oxidation of zinc. The best method of introducing small amounts of the latter is by means of Muntz or brass bar scrap with the initial copper charge.

Q.—Which type of furnace condition, i.e., oxidising or reducing, gives the highest metal loss in melting 70/30 or yellow brass?

A.—Ninety-nine foundrymen of every hundred contend that oxidising melting conditions will give the greatest metal loss in the casting of brass, particularly so far as zinc is concerned. This appears incorrect following the work of Genders and Bailey, who have proved that reducing conditions lead to highest zinc losses. The experimental method utilised by these investigators consisted in heating for 30 min. a small quantity of the alloy (30 grms.) in a tube furnace through which either air, nitrogen containing a small percentage of oxygen or hydrogen could be passed in a regular stream. The furnace atmospheres obtained from the passage of these gases duplicate oxidising, neutral or reducing conditions obtained in practice. The loss in weight of the metal sample after treatment was as follows:—

Alloy.	Treatment.	Loss. Per cent.
70/30 brass ..	1,050 deg. C. in air ..	1·7
	1,050 deg. C. in nitrogen (+ 2 per cent. O) ..	4·7
	1,050 deg. C. in hydrogen	12·6
Phosphorus brass (0·05 per cent. P)	1,050 deg. C. in air ..	15·1
	1,050 deg. C. in hydrogen	16·4

Pure brass in the molten state, when exposed to air or oxidising conditions, is rapidly covered by a surface film of oxide which has the effect of reducing the evolution of zinc. The thinner film formed under nearly neutral conditions permits a greater zinc loss to take place, but this is still much less than that obtained when the formation of the oxide film is entirely prevented as arises in the presence of hydrogen. Furthermore, these conditions do not apply to molten brass containing even small amounts of phosphorus. This is due to the fact that phosphorus removes the oxide film from the surface of the brass and high zinc losses arise with any type of melting atmosphere. It should, however, be mentioned that phosphorus will not necessarily prevent the formation of the oxide film in all brasses and is not effective in the presence of aluminium such as arises in the special high-tensile cast alloys. The affinity of aluminium for oxygen at melting temperatures is so much higher than that of phosphorus that a phosphorus-aluminium brass behaves as if phosphorus were absent.

Q.—How does one make silicon-carbide adhere to the surface of cast-iron plates for the purpose of making potato peelers?

A.—The production of cast-iron plates with a silicon-carbide skin for potato peelers is usually carried out by specialists who are rather secretive about their particular process. The method normally adopted consists of depositing a layer of silicon-carbide grit of suitable size on the mould surface. One method successfully applied is to spray or paint the pattern surface with linseed oil and to scatter the grit evenly over the pattern in such a way that distribution is equal and that it sticks there by means of the linseed oil.

It is assumed that the pattern will be mounted on a moulding-machine plate or on a board. If the operation is carried out by a moulding machine, then it is essential to use a squeeze-type machine. Jarring and jolting machines are unsuitable because the silicon-carbide tends to get in the mould surface.

As an alternative to squeeze-type machine moulding, however, hand ramming can also be successfully used. Naturally, care has to be taken to see that the grit is not too much disturbed or allowed to penetrate the mould skin. It is also necessary to see that a suitable size of grit is used. This must be fairly large, because small grit tends to be dispersed by the metal stream from the runners. It may also be necessary for the inquirer to experiment with various types of runners in order to reduce any disturbance to a minimum. Most people prefer to use metal patterns rather than wooden patterns for this process, because the latter tend to absorb linseed oil.

Standard Road Traffic Signs (Cast Metal and Posts)

The British Standards Institution has just issued a Specification relating to the construction of road traffic signs. It deals with the material, quality and finish of cast-metal signs, the material, quality, dimensions and finish of the posts, and general requirements for the fittings for connecting the sign to the post. The number and size of reflectors in the symbols of certain of the warning signs prescribed in the Ministry of Transport Regulations are also laid down. The optical properties of reflectors and reflecting media are not included in the present issue but they are being investigated and it is intended to issue requirements for them later as an addendum to the Specification. In the meantime certain general conditions with which reflectors and reflecting media shall comply are given pending their more complete specification. The Specification provides for any shape of concrete post desired by the purchaser but a standard design has been included. The Specification has been divided into three sections dealing respectively with the signs themselves, the posts and the fittings. Copies of the B.S. 873-1939 may be obtained from the British Standards Institution, 28, Victoria Street, London, S.W.1, price 2s. (2s. 2d. post free).

Moulding Ships' Propeller Wheels*

By M. WAYMAN

Not until 1837 was the ship's propeller as at present designed brought into being, and since then there has been little change. When the first efforts were made to drive ships by means other than paddles, long continuous screws were used. This method proved to have some advantage over the paddle system, and further experiments showed that shortening of the screw yielded better results. Eventually the idea of a

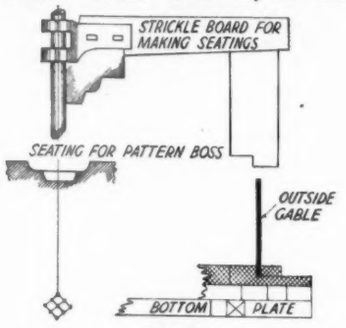


FIG. 1.

single screw divided into two, three or four blades was arrived at.

To-day, each designer has his own conceptions as to the shape and dimensions of the blades. Actually, the type, size and shape of propellers

FIG. 4.—BLADE FORMED IN SAND FROM TEMPLATE STRIPS.

are controlled almost entirely by the type, power and speed of the engines which will propel them. The duty of the foundryman is confined to deciding upon the method by which they should be produced.

A mould for a three-bladed propeller built

FIG. 6.—TOP PART LIFTED AND SUSPENDED FROM CRANE.

up in loam is illustrated in Figs. 3, 4 and 7. In the first place, a substantial bottom plate is required, sufficiently strong to carry the complete load of mould and casting without spring or warpage. The centre of the plate must be arranged to support a strickling spindle rigidly in a vertical position. To the spindle is fixed the strickling board shown in Figs. 1 and 2. A gable fixed to the outer edge of the bottom plate controls the angular pitch of the propeller blade. This gable is usually prepared in the patternshop to the specification provided by the designer. Sometimes a pattern is made for the boss also, but a common practice is to shape the boss in loam with strickle boards made for that purpose. Fig. 2 shows the appearance of the boss when shaped up by the strickle.

After the boss has been dried, the moulder proceeds to build up the first blade in the manner shown in Fig. 2, until he has reached the stage illustrated in Fig. 3, which shows the

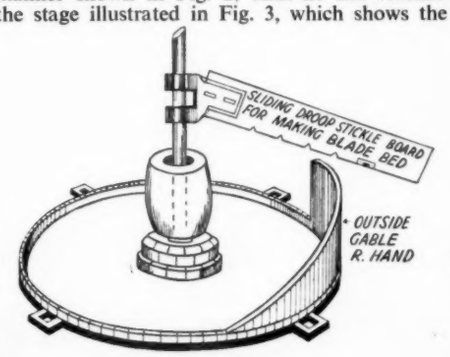


FIG. 2.

form of the face side of the blades. Centre-lines are then inscribed on the face of the mould, and a series of template strips, previously prepared in the patternshop, are fixed in position along these centre-lines, thereby displaying the outline of the shape of the blade. The shape and thickness of the blade are thereafter made up with sand so as to give the effect shown in Fig. 4.

The blade is then covered with a top part such as shown in Fig. 5. This consists of two semi-circular iron castings which conform to the shape of the moulds. A number of 2½-in. holes are cast in it, and through these holes are fixed 1¼-in. square mild-steel bars which are secured in position with cast-iron wedges. After this top part is in place over the propeller blade,

FIG. 7.—ON THE LEFT, A COMPLETED MOULD ENTERING THE DRYING STOVE; ON THE RIGHT, A COMPLETED PROPELLER.

it is built up with 4½-in. loam brickwork, suitably stiffened at top and bottom to resist metal strain arising during casting. When this has been completed, the mould is placed in the stove for drying, after which the tops are lifted away and the sand that formed the shape of the blade is removed. The mould is trimmed up, blacked, and in most cases returned to the stove for further drying.

There are some projections on the top-part castings which are for use in weighting or clamping the mould to secure the tops from lifting when the mould is being cast.

Discussion

MR. R. J. RICHARDSON asked how Mr. Wayman luted up on the boss. Did he lute up and dry on an angle?

MR. WAYMAN demonstrated how he accomplished the luting by the use of clamps and stays.

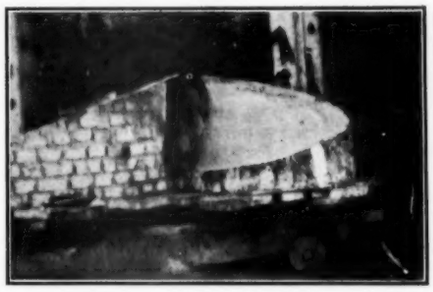


FIG. 3.—MOULD FOR A THREE-BLADED PROPELLER BUILT IN LOAM.

MR. S. PROTHEROE asked how variable pitches were obtained, and whether more than one gable was used.

MR. WAYMAN replied that he had a number

FIG. 5.—FRAMEWORK FOR MAKING TOP PART OF MOULD.

of gables for varied pitches, but in a case where the pitches varied on the same blade, two gables were used, as shown in Fig. 8.

MR. C. E. RICHARDS expressed his preference to ram up a sand top part. He found this to be quite satisfactory, and it was a little quicker to make, perhaps, than a top part in loam.

MR. WAYMAN had seen that method but had never used it himself. He pointed out that

* Paper given before the Wales, Monmouth and West of England Branch of the Institute of British Foundrymen.

he was able to make a 5-ton propeller in from four to five days with the use of two men.

Composition and Erosion

MR. J. J. MCCLELLAND, referring to the necessity of having a metal that would be sufficiently fluid to run the sharp edges of the blade and

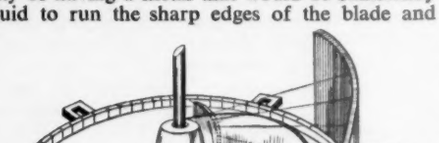


FIG. 8.

at the same time meet the problem of keeping a substantially thick boss solid and free from shrinkage, asked if any special type of metal were recommended. Were English high-phosphorus irons unsuitable?

MR. WAYMAN replied that he would not say the English irons were unsuitable, but in his own case he used from 2½ to 5 per cent. of steel, the balance being hematite, high-grade scrap and Scotch iron. Replying to a further query by Mr. McClelland, Mr. Wayman said he knew of no maker of cast-iron propellers

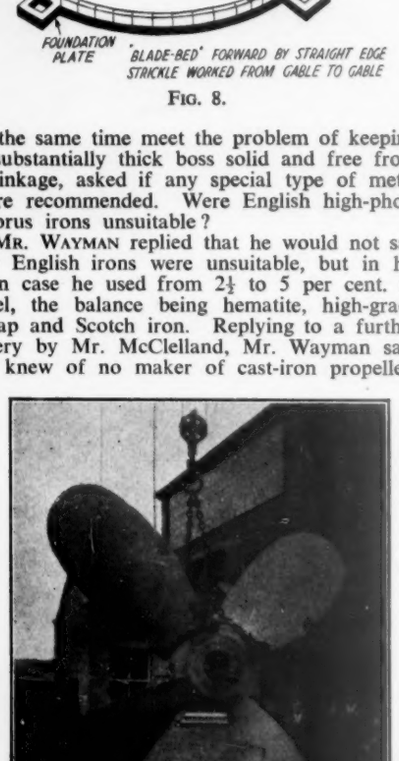


FIG. 9.—PROPELLER WEIGHING 5 TONS 4 CWTS. IT HAS 74 SQ. FT. AREA.

who had overcome erosion. Erosion always affected the propeller at the back first and then worked to the front. Zinc and bronze tips had been tried, but the difficulties had not yet been overcome.

MR. R. J. RICHARDSON observed that he had made steel propellers on very similar lines to the method described by Mr. Wayman, but he used a rammed sand bed with 1 in. of facing sand. Attempts to overcome the erosion had included the tipping of the blades with Stellite.

Future Activities

The BRANCH-SECRETARY explained the nature of the meeting as being experimental. The decision of the Branch Council had been to arrange additional meetings if they thought the attendance would warrant such a step. The present gathering had been a success both as to attendance and interest, and it was therefore agreed that further meetings be held. Mr. S. Southcott was invited to be the opening speaker on the next occasion.

Graphite as a Ladle Addition

ITS EFFECT ON CAST IRON

Certain foundries, more particularly those making light-section castings, add graphite to the iron at the cupola spout during casting. The purpose of this addition is to reduce the tendency of the iron to chill or form hard spots at the edges. In the foundries using this practice, the total carbon in the iron before the addition is generally lower than is normal for the type of work being made. The graphite added at the spout is quite effective, apparently more so than an equivalent amount of residual carbon. In other words an iron of 3.30 per cent. total carbon, 10 points of which are added to the spout, would show less chilling tendency than an iron of 3.30 per cent. total carbon cast without the graphite addition.

With the prevalence of a practice of this type, the question of the effect of ladle additions of graphite on the mechanical properties of the iron becomes of some interest and importance. Therefore, "particularly timely," says the "Iron Age," is the recent report by Ohio State University dealing with the effect of the graphite additions on mechanical properties as well as on the chill depth, the tests being conducted by A. H. Dierker, R. P. Schneider and H. H. Dawson.

The melts were made in a small experimental cupola, and the same metallic charge was used for each run. Variations in total carbon between the different runs was secured by variations in cupola operation. The charge consisted of 40 per cent. steel scrap, 22 per cent. pig-iron, and 38 per cent. cast scrap.

One thousand pounds of metal was tapped into an insulated ladle which had been well preheated. Hand shanks filled from the large ladle were used in pouring the test castings. The graphite additions were made as the hand shanks were being filled. Each shank held approximately 40 lbs. of metal, and 20 grms. (0.7 oz.) of graphite was added in each case; hence the amount added was approximately 0.11 per cent. The graphite added was of two different types, artificial and natural. The natural graphite was of two kinds, a rather coarse material known as No. 8 Mexican and widely used for this purpose, and a fine powdery material. The artificial graphite was of three grain sizes, through 8 and on 14 mesh, through 14 and on 35 mesh, and through 35 mesh.

Thirteen ladles of iron were poured from each run, two with each type of graphite addition and three with no additions. The three standard A.S.T.M. transverse bars were poured as test specimens. Tensile specimens were machined from broken halves of the transverse bars. The chill test was a type widely used in motor-vehicle foundries.

Tapping and pouring were done as quickly as possible to secure a minimum temperature drop in the metal during the pouring operation, and the drop was judged to be less than 50 deg. C. between the first and last casting period.

Table I gives a summary of the mechanical tests of all the test-bars poured, the tests being carried out according to A.S.T.M. specifications A-48-36.

It was hoped in the investigation to determine the best type and size of graphite to use for the additions. Although the detailed results indicated the coarser sizes of artificial graphite to be slightly better, the data are not at all conclusive and much additional work will have to be done before definite information along this line can be obtained.

As has been stated, the primary object of the investigations was to determine the effect of graphite ladle additions on mechanical properties and on the chilling tendency of the iron. The results indicate that:—(1) Graphite ladle additions do definitely reduce the chilling tendency of cast iron. (2) Despite the reduction in the tendency to chill, the mechanical properties of iron castings are not affected in any important degree by small additions of graphite at the cupola spout.

TABLE I.—*Influence of Graphite as a Ladle Addition.*

	Melt No. 8.		Melt No. 9.		Melt No. 10.	
	None.	Graphite.	None.	Graphite.	None.	Graphite.
Chemical analysis—						
T.C	3·05	3·14	3·40	3·43	3·10	3·17
Si	1·91	—	2·19	—	2·37	—
Mn	0·37	—	0·44	—	0·45	—
S	0·116	—	0·104	—	0·120	—
P	0·231	—	0·234	—	0·254	—
Chill depth (in.)	0·219	0·136	0·138	0·086	0·126	0·072
0·875-in. diameter bar—						
Transverse strength (lbs.)	—	1,893	1,500	1,532	1,975	1,906
Deflection (in.)	—	0·189	0·185	0·191	0·218	0·211
Tensile strength (tons per sq. in.)	—	21·6	15·4	15·0	19·4	19·8
Brinell	—	227	201	194	217	222

Book Review

Iron and Steel To-day. By John Dearden, B.Sc. Published by the Oxford University Press, Warwick Square, London, E.C.4. Price 4s. 6d. net.

This book is the latest addition to the series "The Pageant of Progress," and can be classified mentally as a work of general interest to appeal to the serious reader. It is neither a textbook for metallurgical students nor a work of reference for the technician, but is rather a meticulously correct and interesting account of the processes used by and the progress and potentialities of the United Kingdom iron and steel industry. Such books are difficult to compile, for usually the author gives too much prominence to the section in which he himself has specialised. Mr. Dearden has certainly produced the best-balanced description of the industry so far available to the public. The iron foundry as it exists to-day is given its proper perspective, possibly for the first time in history.

Beyond stating that there are thirteen chapters which take the subject from iron ore to "grades of steel and their classification," the reviewer does not propose to catalogue the chapter headings, as they are the obvious ones and follow logical sequence. The illustrations are with one exception uniformly excellent.

In our opinion, this book provides a cheap method of obtaining accurate and easily assimilated information of the major sections of the iron and steel industry, and as such it can be strongly recommended.

V. C. F.

Solubility of Nitrogen in Molten Iron-Silicon Alloys*

By J. C. VAUGHAN, Jun., and JOHN CHIPMAN

Although a considerable amount of practical importance attaches to systems involving gases and molten metals, little is known regarding the effects of alloy elements upon the solubility of gases in liquid iron. The solubilities of hydrogen[1] and nitrogen[2,3] in pure liquid iron are known, and it has been shown that small amounts of silicon and aluminium[3] exert only a small effect upon the solubility of nitrogen, but greatly increase its rate of solution. This Paper presents the results of a study of the solubility of nitrogen, at pressures approximately one atmosphere, in molten iron containing up to 15.8 per cent. silicon.

Experimental Method

There are two general methods by which the solubility of a gas in a molten metal may be determined. In the first, which Sieverts[1] employed, the gas is measured from a burette into the enclosure containing the metal and the amount absorbed is found by subtracting from the total volume that of the dead space in the container. The second method, which was used successfully for pure liquid iron, is to expose the molten metal to the gas until absorption ceases, then to solidify and analyse the metal. In either method the stirring produced by inductive heating prevents the development of a stagnant layer at the metal surface and ensures actual attainment of equilibrium. Obviously, the second method is accurate only when the saturated metal is capable of solidifying without gas evolution. Since the rate of solution of nitrogen in iron is increased by the presence of silicon, it was to be expected that the rate of evolution would be correspondingly increased, and for this reason the first method was selected.

A sketch of the furnace is shown in Fig. 1. A small high-frequency coil having 17 turns fitted closely around a fused silica tube, 2 in. in diameter, in which was placed, on a bed of 60-mesh alumina sand, an alundum thimble of 1-in. inside diameter containing the metallic charge. Around the thimble was poured alumina sand, which served to fill space, decrease radiation loss, and support the thimble in a vertical position. The sand used was carefully measured in a graduated cylinder; the same amount was used each time, and was not packed down; consequently conditions were fairly uniform for each run, and the blanks made were applicable throughout. The sand was cleaned with acid and thoroughly washed after using, and could be employed over and over; but a new thimble was required for each run. Frequent acid-cleaning of the silica tube was also necessary, to remove the coating of sublimed metal. A molybdenum ring cut from 0.012-in. sheet, with an outside diameter of 1 in. and a ½-in. hole, was suspended by molybdenum wire to a level about ½ in. above the surface of the metal, in order to prevent bridging of the charge. The ring became very brittle; some molybdenum was vaporised, and a small amount of metal from the charge condensed upon it. It cracked on occasions, and had to be replaced regularly. Several alundum discs, drilled to ½ in. in the centre, and two concentric fused silica rings about 2 in. high were employed as space fillers, resting on top of the thimble. The discs were renewed each time, while distilled metal made necessary the cleaning of the silica rings after every run.

A water-cooled brass head, providing an inlet tube for nitrogen and a glass window held tightly against a rubber gasket by a threaded brass piece, was cemented to the top of the silica tube by means of Picein wax, which was kept cool by a copper coil mounted on a brass sleeve and connected to the silica tube by zinc-silicate cement. A skirt on the head dipped into the wax about ½ in., and although the original sealing job was often troublesome, no leaks ever developed during a run.

The nitrogen supply was tank nitrogen, 99.8 per cent. pure, and practically free of argon. It was purified by passing it through two glass tubes containing copper lame at 500 deg. C., and a drying tower containing phosphorus pentoxide. A tube packed with surgical cotton removed any P_2O_5 that might be blown from the drying tower. From this tube the nitrogen entered the gas burette, which had been calibrated over its entire length by mercury weighing. A side tube opening to the air through a bubbling bottle made it possible to flush the purification train with nitrogen before filling the burette. Mercury was used to displace the gas in the burette. Instead of a levelling bulb, an aspirator bottle set above the level of the top of the burette, and connected through stopcocks to the air and to a vacuum line, was employed. After a fair amount of practice it became a simple matter to control the mercury level and the pressure in the burette. A side tube of the same diameter as the burette, and connected to it and to the mercury supply at the bottom, was used to indicate the gas pressure.

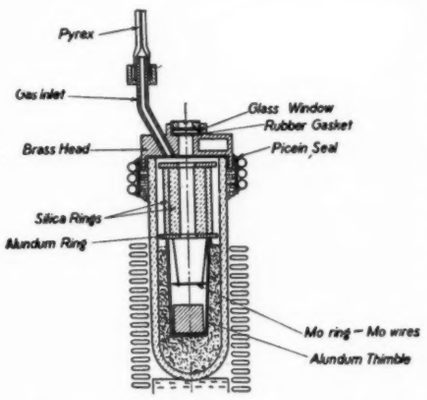


FIG. 1.—FURNACE USED IN EXPERIMENTS.

From a two-way stopcock at the top of the burette, glass tubing ran to the nitrogen supply and to the furnace. The line to the furnace was of 1-mm. capillary tubing, since it was desirable to cut the volume to a minimum. Two side lines ran off from the capillary tube, one through a stopcock to a vacuum pump, the other to a mercury manometer.

The volume of the gas space inside the furnace and connecting tubing was found to be 125 ml., and this volume was kept constant throughout the series of experiments by controlling the size of the charge and the amount of alumina packing. The "hot volume" or the amount of gas measured at room temperature required to fill the furnace containing a molten charge was, of course, very much less than this and was subject to variation with the temperature of the charge. Using liquid nickel, which was found to dissolve virtually no nitrogen, this volume was found to be 58 ml. at 1,500 deg. and 55 ml. at 1,650 deg. C.

Two iron-silicon alloys were prepared by melting electrolytic iron and commercial silicon (98.5 per cent.) in a magnesia crucible under an atmosphere of hydrogen. The charges were made up by appropriate amounts of these alloys, which contained, respectively, 0.005 and 15.83 per cent. silicon.

Temperatures were measured with a "Pyro" optical pyrometer, which was checked frequently at the melting point of iron. There was no difficulty in obtaining accurate temperature measurements as long as the melt was in vacuum, but during the absorption a considerable amount of smoke was formed, which condensed on the sight glass and made accurate measurement impossible.

The procedure in carrying out a determination was as follows: A weighed amount (75 grms.) of iron-silicon alloy was placed in the crucible, which was then inserted in the tube and surrounded by a measured volume of alumina sand. The molybdenum discs and other furnace parts were placed, the cover cemented on and the furnace was evacuated. The charge was melted in vacuum and thoroughly outgassed until no pressure rise could be observed on the manometer when the stopcock between pump and furnace was closed for a 5-min. period.

Nitrogen was admitted rapidly from the burette until the furnace pressure reached atmospheric, after which the pressure was maintained constant and frequent burette readings were recorded. Since the heat loss from the metal is greater in nitrogen than in vacuum, it was necessary to increase the power input slightly just before the gas was admitted. Within 10 min. after the gas was admitted, the sight glass became fogged and further temperature measurements were impossible. During the first 10 min. of the absorption period, therefore, it was necessary to adjust the power input to produce the desired temperature, after which the power was held constant for the remainder of the run. This procedure was based upon experience gained with silicon-free melts that did not fog the window. The temperature control was much less certain than could have been desired. It was estimated that all the melts except No. 4, which was hotter, were made between 1,600 and 1,660 deg. C.

The absorption curves of representative runs are shown in Fig. 2. The rate of absorption of nitrogen during the first few minutes was extremely rapid in all melts that contained silicon. Within a few minutes, absorption ceased, and was followed by an apparent evolution of gas. This strange behaviour was at first attributed to fluctuation of temperature in the furnace, but in the light of personal theoretical explanation of the results, which will be discussed later, it now seems possible that in some cases an actual evolution of gas occurred as a result of the restoration of equilibrium following an initial supersaturation.

This period was followed by a prolonged slow absorption of gas, which, however, never occurred in the absence of silicon. The rate of this absorption was practically constant as long as the metal was molten, extending in some cases as long as 3 hrs. It appeared that this slow absorption was not taking place in the melt itself, but in the distilled metal above the melt. Enough of this material was collected for analysis, and was found to contain 0.21 per cent. nitrogen. The slow absorption was always accompanied by the appearance of smoke in the furnace, and tentatively both phenomena may be ascribed to the formation and condensation of silicon nitride.

The best values for the solubility of nitrogen in the melt will be taken as the minimum points

* A Paper read before the American Institute of Mining and Metallurgical Engineers. Mr. Vaughan is a member of the staff of the Union Carbide and Carbon Research Laboratories, Niagara Falls, N.Y., and Mr. Chipman is Professor of Metallurgy, Massachusetts Institute of Technology, Cambridge, Mass.

in the curves of Fig. 2. These points are recorded in the third column of Table I.

During the solidification of each melt, burette readings were taken at ½-min. intervals in an effort to determine the amount of gas evolved. These readings, plotted against time, showed an offset at the moment of solidification, which was small when no gas was evolved and fairly large when gas evolution was pronounced. From the shapes of the curves, an estimate of the amount evolved was obtained and recorded in the fourth column of Table I. The solidified

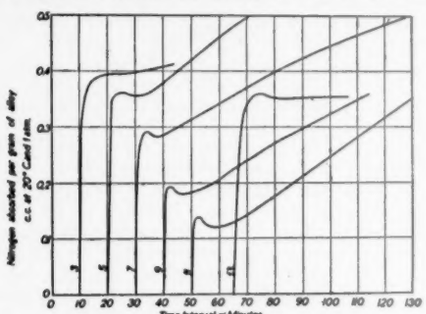


Fig. 2.—Absorption Curves of Representative Runs.

metal was cut vertically into representative segments, which were analysed for silicon and nitrogen, the latter by vacuum fusion; the results are recorded in the table. It is probable that during cooling some gas was evolved from the metal while it was yet in the liquid state, and for this reason the sum of the fourth and fifth

Table I.—*Experimental Data on Solubility of Nitrogen in Iron-silicon Alloys at 1,600 to 1,660 deg. C.*

Heat No.	Si. Per cent.	Nitrogen. Per cent.		
		Total absorbed.	Evolved.	Analysis.
1	0·28	0·042	—	—
2	0·66	0·046	0·011	0·030
3	1·19	0·046	0·008	0·031
4	2·01	0·049	0·008	0·026
5	2·52	0·041	0·004	0·023
6	3·34	0·0355	0·008	0·017
7	3·99	0·0325	0·006	0·018
8	5·19	0·0275	0·009	0·014
9	7·53	0·021	0·007	0·013
10	9·79	0·014	0·000	0·014
11	12·45	0·014	0·000	0·006
12	15·83	0·0082	0·000	0·005
13	0·001	0·041	0·002	—
14	0·004	0·037	0·000	—

columns of the table is not expected to agree precisely with the third column, which is considered the most probable value of the actual solubility.

Interpretation of Results

The initial increase in nitrogen solubility followed by an abrupt decrease was, to say the least, unexpected. The simplest explanation that can be offered is briefly the following: In liquid iron, nitrogen dissolves as a compound containing several atoms of iron and one atom of nitrogen per molecule. The activity of iron is greatly diminished by silicon, probably by formation of a compound, and the decrease in nitrogen solubility from about 2 per cent. silicon onward is due to the decrease in free iron in the solution. The initial increase in solubility is the result of the formation of a silicon nitride of limited solubility in the melt. The maximum in the solubility curve occurs when the silicon content is sufficient to form this nitride; further increases in silicon content exert a negligible effect upon the amount of silicon nitride dissolved.

These hypotheses are in agreement with other known facts regarding the elements concerned. An iron nitride containing one atom of nitrogen accounts for the proportionality of its concentration to the square root of pressure. Silicon dissolves in liquid iron with evolution of heat and its activity is less than would be expected for an ideal solute.[4] Silicon and nitrogen form several nitrides, one of which at least is fairly stable at 1,600 deg. C. From the data of Hincke and Brantley[5] the dissociation pressure of Si_3N_4 at this temperature is only about 16 mm. Finally, the coincidence of the break in the rate-of-solution curve with formation of smoke in the apparatus is interpreted as the precipitation of solid silicon nitride from the liquid iron solution and its gradual volatilisation and condensation in colder parts of the furnace.

It is interesting to speculate on the nature of the compounds of iron and silicon and of iron and nitrogen, and the data provide the basis for

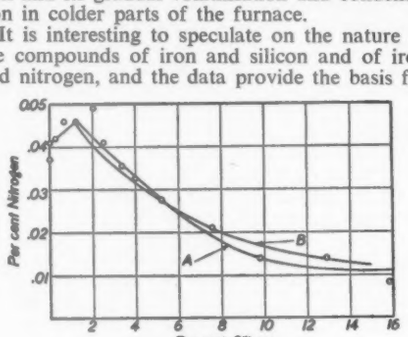


Fig. 3.—Computation *versus* Experimental Results.
Curve A, Fe_3Si and Fe_6N; Curve B, FeSi and Fe_6N.

such a speculation, although they are not sufficiently precise to permit a unique solution.

The simplest numerical method of approach is to assume a formula for the iron silicide, compute the mol fraction of free iron at several concentrations and determine the power to which this must be raised to parallel the curve, which in turn fixes the formula that must be ascribed to the iron nitride. The amount of nitrogen dissolved as iron nitride is then calculated at several percentages of silicon; above the peak of the curve a constant solubility of silicon nitride is assumed and the sum of the two gives the total nitrogen solubility. Up to the peak, which is taken as 1.2 per cent. silicon because of experimental uncertainties in the point at 2 per cent., the amount of silicon nitride is taken proportional to the percentage of silicon.

The results of two such computations are shown in Fig. 3 in comparison with the experimental results, which are shown as circles. Curve A corresponds to Fe_3Si and Fe_6N, while curve B represents FeSi and Fe_6N. Although curve A represents the data somewhat more closely than any other combination the authors have tried, it is evident that other possible combinations lead to results that also fit the data within the limits of experimental error.

The nature of the compounds that occur in the solid state unfortunately throws no light upon the constitution of the liquid solution. The authors would not be justified in preferring curve B to curve A because of the stability of FeSi and the non-occurrence of Fe_3Si in the solid state. It is of interest in this connection that Darken,[6] in a study of the iron-carbon-silicon system, has found that the solubility of graphite in liquid iron-silicon alloys can be satisfactorily represented on the basis of the occurrence of Fe_3Si in the melt.

Acknowledgments

The authors wish to express their thanks to Mr. T. E. Burke, who calibrated the gas burette and carried out preliminary determinations of solubility that were substantially in agreement with those reported in this Paper.

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Benefits of Control

By "Onlooker."

In one way and another the system of control on commodities as set up by the Government has called forth a strong volume of protest since the war began, and there can be little doubt that in some instances there have been good grounds for complaint and criticism. This outcry is in many respects a healthy sign, for while no one would dream of setting out to defend the blunders that have been made, the reaction against control indicates a vigorous trading spirit which has always resented outside interference. In the exercise of their function the controllers may not always have acted too wisely, but during a time of national crisis and the existence of abnormal conditions, some confusion is inevitable, and errors of judgment cannot fail to occur.

Nevertheless, the principle of control, aimed as it is at profiteering either in price or by way of hoarding material, is thoroughly sound, and has so far been instrumental in saving the taxpayer an immense sum of money. One has only to think back to the years 1914-18 to realise that, and if on this occasion the system of control has not so far shown itself to be altogether perfect, the country is on balance very much better served than on the occasion of the last national emergency.

Pressure Eased by Export Embargo

In metals, for example, one may well wonder what would have happened without the control to keep the price in check, for outside the United Kingdom values have gone ahead in no uncertain manner. That is not all the story; it does not follow that the quotation for copper would, for example, have been no higher than £70, which is about the value on the Continent, or spelter more than £30. Just before the war broke out, there was on the London market a backwardation of 5s. on standard copper as the result of keen bidding for early metal, in which Germany was identified as a buyer. That, one might say, was just the beginning of wartime pressure, but the situation was eased by the embargo which the Government laid on exports, thus eliminating Continental competition.

There are advantages and disadvantages in a free market such as Whittington Avenue, but there can be little doubt that if metals had been allowed to find their own level speculative buying of such essential wartime commodities would, in competition with a trade demand magnified many times by the call for munitions, have forced quotations up to very high levels. Moreover, the spirit of panic would have entered in, for nobody knew just how the country stood in regard to supplies of non-ferrous metals, and once a commodity situation gets out of hand it takes some putting right again.

The control of metals was definitely a wise step, and has already saved the country a very large sum of money, for the prices fixed are eminently reasonable, and in fact decidedly cheap by comparison with pre-war rates. Whether they can be kept where they are remains to be seen. The price basis of the contract made by Canada with the Ministry of Supply is, it is understood, £48 10s. f.o.b. Canadian port, and electrolytic copper is on offer to United Kingdom consumers at £51 c.i.f., so that there is a margin of £2 10s. to cover freight and insurance across the Atlantic. With the advance in freights and the cost of war-risk insurance to face, this sounds very lean, and in view of the low rate at which the trade is being supplied some advance in values would occasion no surprise. However, this is not likely to be made, and under control the country is assured of proper distribution of metal supplies at reasonable prices.

Elastic Properties of Cast Iron*

By ALEXANDER I. KRYNITSKY and CHARLES M. SAEGER, Jun.

INTRODUCTION

The term "elastic properties" as used in this discussion connotes those complex properties that determine the behaviour of cast iron under load. They may be determined from the results of transverse bending tests.

All of the properties of cast iron are related to and, to a large extent, determined by the structure, which consists of a coherent metallic matrix throughout which particles of graphite are dispersed. The presence of these particles decreases the amount of metallic material available to resist stressing in a given section and causes non-uniform distribution of stresses, but the quantitative interpretation of these effects is as yet unsettled. In the consideration of the behaviour of cast iron in compression, the question whether the spaces occupied by the graphite particles should be considered as voids or as spaces filled with compressible, partly compressible, or incompressible material, has been discussed by several authors, for example, MacKenzie[1], Thum and Ude[2], Meyersberg[2a], Pearce[3], and Bolton[4]. Aside from the general weakening or depreciation of properties, because of the presence of the relatively soft graphite flakes, the heterogeneous structure frequently leads to erratic results in determinations of the properties and renders their interpretation uncertain. Such factors as the composition, shape, size and surface condition of the specimen, and the details of the testing procedure are of greater importance in determining the properties of cast iron than in similar determinations on other metals, steel, for example.

The determination of the elastic properties of cast iron is further complicated by the fact that even moderate stresses produce plastic as well as elastic deformation in this material. Attention was called to this fact approximately 50 years ago, by de Segundo[5] and by Bach[6]. The observations of these early investigators have been confirmed by subsequent workers, and it had been definitely established that plastic deformation of cast iron begins under low loads. In the determination of elastic properties by means of transverse tests it is necessary, therefore, to define complete stress-deflection curves by means of step-wise loading, and to determine for each load not only the total deflection under load but also the plastic deformation or permanent set that remains in the bar after the load has been removed. The difference between the total and the plastic deformation is the elastic deformation.

Interpretation of the results of transverse tests and of the data computed from these results, for example, modulus of elasticity, resilience, etc., in terms of properties such as brittleness, toughness, ductility, and energy required to break a bar has been widely discussed but the correlations have not been entirely satisfactory partly because of the difficulties of conducting transverse tests, with resultant uncertainty regarding the accuracy and reliability of the data obtained.

Preliminary results of this investigation, presented in a previous publication[7], showed that various properties, including the transverse strength and running quality during casting as well as the size and distribution of the graphite flakes in each of the irons used, were affected by the maximum temperature to which the liquid metal had been heated. Computations of the modulus of elasticity were made, based on the data obtained under loads of 1,200 lbs. and also under the loads that caused rupture. These results clearly showed the need for a more detailed and systematic study of the stress-strain relations in cast iron. For the present investigation, it was decided to prepare test-bars from each of several irons, representing different maximum heating and pouring temperatures, and to record, as accurately as possible, the complete stress-strain curves up to the breaking point of each bar, by means of observations of the successive deflections under increasing loads and the permanent set that accompanied the application of each load.

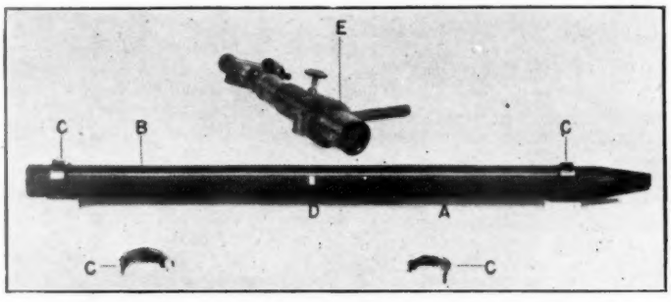

FIG. 1.—APPARATUS FOR MEASURING DEFLECTION OF TEST-BARS UNDER TRANSVERSE LOADING.
A, test-bar. B, rubber band. C, clamps. D, reference mark. E, micrometer telescope.

METHOD OF MEASURING DEFLECTION

One of the first requirements for the proposed investigation was an improved method of measuring the deflection of the bar under load and the permanent set in the bar after the load was removed. Direct observation of the changing position in space of a reference mark on the bar is unsatisfactory, because it involves a number of assumptions, for example, the supports and the testing machine as a whole must remain immovable and there must be no penetration of the supports into the specimen. To avoid these possibilities of error a new method of measuring deflection was devised, as follows:

In this new method of measuring deflection of bars under transverse loading, a rubber band, B, is stretched tightly along the length of the bar, A, and is held in position by two clamps, C, as shown in Fig. 1. Metal strips on the inner surface of the clamps keep the rubber band near to, but not in contact with the surface of the bar at all times. The spacing between the two clamps is the same as that between the supports for the bar in the testing machine, 18 in. in these experiments. Reference mark D is attached directly to the bar, midway between the clamps. The bar is placed in the testing machine and the micrometer telescope, E, mounted at a distance of 20 in. from the bar, is used to measure the distance between the lower edge of the rubber band and the top edge of the reference mark. When the bar deflects under load, the reference mark moves away from the rubber band, which remains as a straight line connecting the central portions of the bar at the two supports. The distance between the rubber band and the reference mark therefore indicates the deflection of the loaded bar and a similar measurement after the load is removed indicates the permanent set. With this apparatus, the maximum error in reading deflections, including errors in the micrometer telescope and personal errors of the observer, was found to be less than ± 0.002 in.

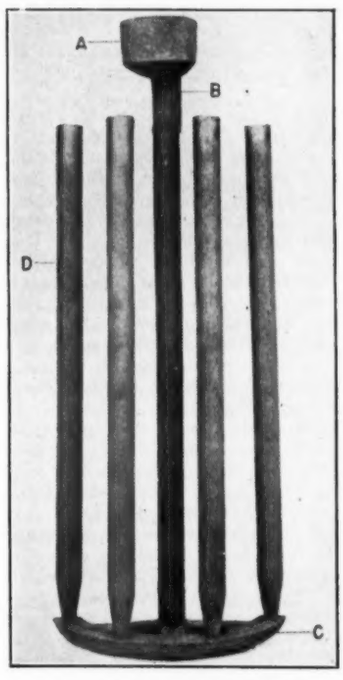

FIG. 2.—TRANSVERSE TEST-BARS, AS CAST.
A, pouring basin. B, down gate. C, semi-circular feeder for bottom pouring. D, vertically-cast bars.

The principal advantage of this simple method of measuring deflections is that the readings are made entirely independently of the testing machine and supporting fixtures. A further advantage is that observations can be continued up to and including the breaking load without danger to sensitive optical apparatus or to delicate instruments such as extensometers.

MATERIALS AND PREPARATION OF TEST-BARS

Three types of iron, of the compositions shown in Table I, were used in this investigation. Iron A is a stove-plate pig-iron remelted with the addition of 10 per cent. of open-hearth ingot iron. Iron B approximates the composition of a medium cylinder iron, although the carbon is slightly high and the phosphorus is somewhat low. Iron C represents a soft iron such as is used for general castings.

TABLE I.—*Percentage Composition of Stock Pig-irons.*

Iron.	T.C	Si.	Mn.	S.	P.
A	3·44	1·40	0·15	0·020	0·46
B	3·79	1·40	0·63	0·062	0·181
C	3·44	2·43	0·77	0·050	0·395

Cylindrical bars for the transverse tests were cast in groups of four, as shown in Fig. 2. The pattern was moulded in a three-part cylindrical flask with the full length of the test-bars con-

* Extracted from Research Paper RP 1176 of the U.S. Bureau of Standards.

tained in the cheek. Each flask contained two groups, that is, eight bars. The patterns were moulded in a mixture of eight parts of moulding sand and one part of coal dust, tempered to approximately 7 per cent. of moisture. The mould cavities were faced with non-graphitic carbonaceous material* of commercial origin. The castings were bottom poured with the bars occupying vertical positions in the mould. By this procedure, as described in a previous publication,[5] test-bars can be produced which are satisfactorily uniform in diameter throughout their length and free from burnt-on sand or other surface defects. The cylindrical section of each bar was 21 in. in length and 1.2 in. in diameter.

Charges of 230 lbs. of iron, in a commercial magnesia crucible, were melted in a high-frequency induction furnace of the tilting type. Each melt was heated to a predetermined maximum temperature of 1,400, 1,500, 1,600, or 1,700 deg. C., and was maintained at this temperature for approximately 1 min. The metal was then allowed to cool until the temperature was 250 deg. C. above the liquidus temperature† of the iron used in that particular melt. A set of four bars was then cast as a unit by pouring the metal directly from the tilted furnace into the mould. The metal remaining in the crucible was allowed to cool to the next pouring temperature, 200 deg. C. above the liquidus, and another set of four bars was cast. By continuing this procedure, a set of four bars was cast at 150 deg. C. above the liquidus, and a final set at 100 deg. C. above the liquidus. Sixteen test-bars, representing four pouring temperatures, could be thus obtained from a 230-lb. melt that had been heated to a definite maximum temperature. The bars were allowed to remain in the moulds for at least 18 hrs. after casting.

Temperature measurements of the molten iron up to 1,600 deg. C. were made with a platinum--platinum 10 per cent. rhodium thermocouple which was protected by a closed-end, glazed porcelain tube inserted in a closed-end graphite tube. The portion of the graphite tube that came in contact with the molten iron was protected by a coating of aluminium oxide covered with a mixture of 95 per cent. of zirconium silicate and 5 per cent. of bentonite.

Temperatures above 1,600 deg. C. were measured with an optical pyrometer which had been previously calibrated with the thermocouple in the temperature range of 1,400 to 1,600 deg. C.

TESTING PROCEDURE

A universal testing machine of the hydraulic type of 20 tons capacity was used for the transverse tests. The rate of loading of all bars corresponded to 0.12 in. per min. travel of the free cross-head of the testing machine.

The test-bar, equipped with the rubber band and reference mark, as shown in Fig. 1, was mounted in the testing machine on two supports of the roller type, at a span of 18 in. The bar was adjusted until the rubber band lay in the horizontal plane of the neutral axis of the bar. A load of 50 lbs. was sufficient to seat the bar firmly, but was not enough to produce noticeable plastic deflection, was applied and the distance between the edge of the rubber band and the top of the reference mark was determined as a zero reading. The bar was then loaded in a series of steps (100 or 200 lbs. each) until the breaking load was reached and the deflection of the bar under each of the loads was recorded. After the load reached 800 or 1,000 lbs. each application of a load was followed by unloading to the original 50-lb. load, and the permanent set in the unloaded bar was determined. Attempts to record the small permanent deformations that resulted from loads of less than 800 or 1,000 lbs. were seldom made. Unloading the bars did not affect the deflection under subsequent loads; the breaking loads and the load-deflection curves of duplicate bars were practically identical when one of the bars was loaded in the manner just described and the other was progressively loaded without unloading between successive loads.

* Approximate analysis: 4 per cent. of volatile; 74 per cent of fixed carbon; 22 per cent. of ash.

† The liquidus temperature of each iron was estimated from its composition, according to the procedure described in a previous publication.[7]

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(To be continued.)

Research in Relation to Steel Metallurgy

Dr. W. H. Hatfield, F.R.S. (Director of the Brown-Firth Research Laboratories), in the course of an address to the Sheffield Metallurgical Association, strongly advocated the continuance and intensification of research during the war, stressing its tremendous importance and the advantages which must necessarily accrue. He deprecated any suggestion to stifle scientific progress, and emphasised that the research worker could best serve the country by continuing his pursuit of knowledge.

It became apparent, he said, that it was very necessary that fundamental knowledge now available, and its application to industry, should proceed apace throughout the period of the war. This was of vital importance for two reasons. First, because enterprise in technology, next to the achievements of the men in the field, would be the decisive factor in winning the war. Secondly, should the war last four or five years, what would be the position if science and its activities were shut down for the period of the war and those previously engaged in science took up arms? A lapse of four or five years in the progressive development of scientific knowledge affecting their industry was absolutely unthinkable. The work must go on, and at an increased rate compared with pre-war times. When we had won the war we should have to deal with the inevitable aftermath, and the more enterprising we were in the intervening period in developing our science, and assisting and developing the technology of the industry, the better would be the position of the British iron and steel industry to combat foreign competition and to develop the home and foreign markets.

Major Developments since the last War

During the last 20 to 25 years they had seen the advent and exploitation of rustless steels and heat-resisting steels—entirely new products; the magnet had been developed to such a degree that to-day they were ten times as powerful as during the last war. Of course, many other developments could be cited, and there was every promise that the developments of the next 25 years would be at the same pace as the developments of the last 25, always providing that the body of scientific men and applied-science men

(*Concluded on page* 378.)

Notes from the Branches

LONDON

The first meeting of the session of the London Branch of the Institute of British Foundrymen was held last Saturday afternoon at the Charing Cross Hotel, under the chairmanship of Mr. Barrington Hooper, C.B.E. In his opening remarks, MR. HOOPER thanked the members for the confidence they had reposed in him and then shortly reviewed the impact of war conditions on the foundry industry. He expressed the indebtedness of the Branch to Mr. H. W. Lockwood for assuming temporarily the office of honorary secretary in the place of Mr. Daglish, who was serving in His Majesty's Forces. Finally, he referred to the sterling and extremely successful work accomplished by Mr. C. C. Booth, J.P., his predecessor in the chair.

In introducing the lecturer, Mr. F. J. Cook, M.I.Mech.E., the Branch-President said he could never make up his mind as to whether Mr. Cook joined the Institute or the Institute, Mr. Cook. He recalled that the first lecture ever given to the London Branch was by Mr. Cook.

MR. COOK dealt with the layout of foundries, illustrating his remarks with lantern slides and diagrams. He first dealt with jobbing foundries and later described in some detail some of the most modern mechanised plants in the country. A good discussion followed, in which Mr. R. B. Templeton, Mr. G. C. Pearce and Mr. Harwood Brown took part. Mr. Cook was cordially thanked for his lecture, MR. V. C. FAULKNER and MR. C. HOWELL KAIN being the proposer and seconder.

MR. V. DELPORT thanked the Branch-President for his short address, and expressed the indebtedness of the Branch for the enormous amount of work he did in connection with the International Congress.

MR. HOOPER, in the course of his reply, announced that the Council had informally decided to send a Christmas present to all Branch members serving with the Forces.

LINCOLNSHIRE

The Lincolnshire Section of the Institute of British Foundrymen held its first orthodox meeting of the session in the Lincoln Technical College on November 18. Although the committee and members had kept in touch fairly well, this was the first occasion which had the semblance of a full meeting. A brief committee meeting and tea preceded the general meeting.

The committee's arrangement for the altered programme was discussed, and then followed an extremely interesting Paper by Mr. S. A. Horton on "Patterns in Relation to General Foundry Practice." The examples were well chosen and admirably illustrated by lantern slides and diagrams. The discussion was supported by both the moulders present and the minority of patternmakers. The meeting terminated in a good spirit, which augers well for the future of the Section and its programme.

MR. HARBACH proposed and MR. DUNLEAVY seconded a very hearty vote of thanks to the speaker, who suitably replied.

The Section wish it to be known that their meetings will be held for the time being on Saturday afternoons at 3 p.m. at the Technical College, Lincoln, until further notice. On account of the still rather difficult circumstances, they prefer to announce their meetings as they are definitely arranged. It is likely that the full programme will be carried through during the session, even if dates and sequence are altered. The next meeting of the Section will be held on Saturday, December 9, when Mr. S. E. Dawson, F.I.C., will present a Paper on "Melting Furnaces."

Foreign Standard Specifications for Grey Iron*

By H. JUNGBLUTH (Essen)

Dr. Jungbluth's article has been translated at the request of the appropriate sub-committee of the Institute of British Foundrymen. The reaction of specifications on international business is apt to be overlooked, and attention is drawn to the author's statement that "the surprising discovery is made that the German Standard Specification has been adopted as pattern by a considerable number of other countries, a fact which ought to be taken into consideration when drafting the proposals for amendment."

The recent proposals to re-consider the German standard specification for cast iron DIN 1691 suggests a review of the position of standardisation in countries other than Germany. When this is done, the surprising discovery is made that the German Standard Specification has been adopted as pattern by a considerable number of other countries, a fact which ought to be taken fully into consideration when drafting the proposals for amendment.

In what follows it is not intended to draw a simple comparison between the contents of the various standard specifications, in tabular form, for example, but an endeavour will be made to discover the fundamental lines of thought underlying the specifications, and in this way to reveal any unanimity or differences in opinion regarding the requirements which a standard ought to satisfy. The intention is to deal only with standard specifications for grey cast iron and its mechanical properties.

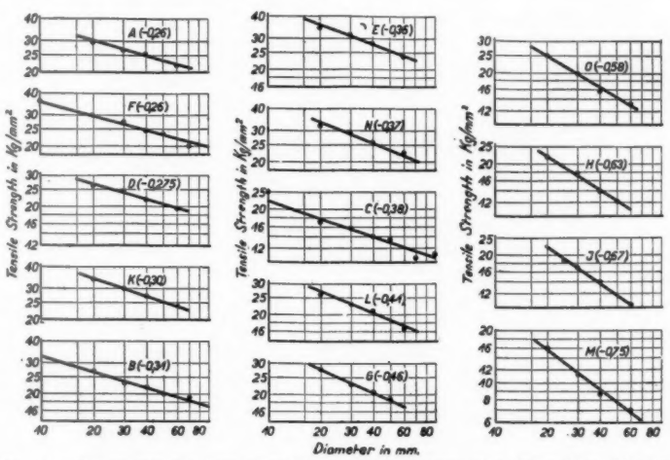


FIG. 1.—RELATIONSHIP BETWEEN TENSILE STRENGTH AND TEST-BAR DIAMETER FOR DIFFERENT KINDS OF GREY IRON (HELLER AND JUNGBLUTH).

The standard specifications of the following countries have been considered: U.S.A., Great Britain, Switzerland, Poland, Norway, Czecho-Slovakia, Hungary, Italy, Holland and Rumania. The author has inspected the standard specifications of U.S.A., Great Britain, Switzerland, Norway and Hungary in the original. With regard to the other countries, use was made of the list prepared by J. Lèonard[1] for the International Committee for the Testing of Cast Iron, giving only the contents of the specifications with special reference to testing. Prof. Körber of the Kaiser-Wilhelm-Institut in Düsseldorf provided the author with a translation of the Norwegian specification by Torolf Krogvig and with a translation of the Rumanian specification by Stefan Nadasan. Mr. Robert Erdös translated the more important portions of the Hungarian standard specification.

Scope of the Standard Specifications

The German standard specification distinguishes grey cast iron having guaranteed mechanical properties from other possible kinds of cast iron by detailing all the other kinds, such as builders' castings, hardware, light and art castings, chilled castings, heat-resisting cast iron, and the like, and indicating their fields of application. With the exception of certain kinds of cast iron having special magnetic properties, however, no figures are specified for these other kinds. It is thus implied that, although standard specifications would be necessary for these other kinds of cast iron, they are included in the category "Machinery castings with and without special specifications as to quality." The category "Machinery castings with and without special specifications as to quality" does not contain any restriction to definite wall thicknesses, so that both the lightest and heaviest castings are included in this standard.

One group of standard specifications other than the German specification proceeds on similar lines, for instance the Swiss, Italian and Rumanian specifications, although as regards Rumania, pearlitic iron and iron for railway material and brake blocks are excluded from the general specification of the Rumanian Standards Committee by special provisions governing the testing of the iron.

A second group of standard specifications incorporates the new idea that the specification relates only to castings having a definite maximum wall thickness laid down in the specification. For instance, Norway solves the problem by specifying in the first place examples of the fields of application of the various standardised kinds of grey iron. In the second place, it is laid down that with regard to acid-proof and alkali-proof cast iron, heat-resistant cast iron, cast iron with special magnetic properties, etc., special agreements outside the framework of the specification are to be made, and that all castings having a wall thickness exceeding 50 mm. (2 in.) are to be excluded from the specification. This is achieved by leaving the testing procedure to such events to special agreements between the customer and foundry.

The same principles are also indicated in the British and U.S. standard specifications. Great Britain has two standard specifications, one for "Ordinary grey iron castings" and one for "High-duty grey iron castings," the fuller definition being given in the classification which is to be discussed later. However, the specifications, with their fuller definitions, apply only to castings having a wall thickness of up to 50 mm. (2 in.). In addition, special agreements are again necessary between foundry and customer. The U.S. specification is restricted by a statement made in the scope to the effect that the specification applies to normal grey iron castings in which strength is the important feature and for which there is no special standard specification of the A.S.T.M. In the case of wall thicknesses above 2 in., special agreements are necessary between customer and producer.

Classification

All the standard specifications discussed in this Paper classify the cast iron according to quality. Now cast iron has the property of wall thickness sensitivity. By this is understood the phenomenon that the same cast iron, when cast with increasing wall thickness, for example in the form of test-bars of increasing diameter, shows a decrease in strength. Fig. 1, taken from a Paper by P. A. Heller and H. Jungbluth,[2] represents this fact, and at the same time shows that the wall thickness sensitivity diminishes with increasing strength of the iron. In Fig. 1, the numbers in brackets at the side of the letters give the tangent of the angle of slope and are a measure of the wall thickness sensitivity. The ordinates and abscissæ are plotted on logarithmic scales. Considering the example shown in Fig. 1, if a tensile strength of 22 kg. per sq. mm. (14 tons per sq. in.) is required in a round bar of 20 mm. (0.75 in.) diameter, it is possible to use material H which, in a normal bar of 30 mm. (1.18 in.) diameter, has a tensile strength of 18 kg. per sq. mm. (11.4 tons per sq. in.).

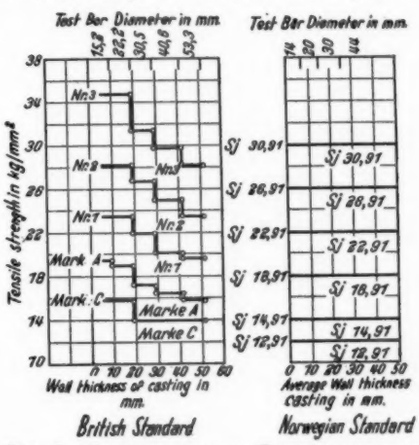


FIG. 2.—EXAMPLES OF THE CLASSIFICATION OF METHODS OF STANDARDISATION.

If, however, the same tensile strength of 22 kg. per sq. mm. be required in a bar of 50 mm. (2 in.) diameter, it will be necessary to use for this purpose a much higher grade of iron, namely grade F, which in a bar of 50 mm. diameter has the required strength of 22 kg. per sq. mm., but in a bar of 30 mm. diameter has a tensile strength of 27 kg. per sq. mm. (17.1 tons per sq. in.). Conditions are similar when the wall thicknesses of castings are compared instead of the diameter of bars. At all events, it must be admitted that the requirement for a tensile strength of 22 kg. per sq. mm. in a wall thickness of 20 mm. is by no means so difficult

* Translated from "Die Giesserel," August 25, 1939, pp. 433-437

to satisfy as the same requirement in a wall thickness of 50 mm. In the latter case, it is necessary to use a much higher grade of iron.

The question now arises as to whether these facts are or are not to be utilised in classifying the standards. Both cases occur in the various national standard specifications. By way of example, in Fig. 2 the British standards, in which the wall thickness sensitivity has been taken into consideration, are compared with the Norwegian standards, in which no such consideration has been made (as is also the case, however, with the German standards). In referring to these two types of classification, it is perhaps possible to speak of a "classification according to material" in the case of the British standard specifications, and of a "classification according to properties" in the case of the Norwegian specification. In the British standard specifications, the quality of the grades of cast iron increases in the series from C to No. 3. The heavy lines indicate the minimum tensile strengths of the grades of iron. If, now, the British designer requires in his casting a tensile strength of, say, 21 kg. per sq. mm. (13.3 tons

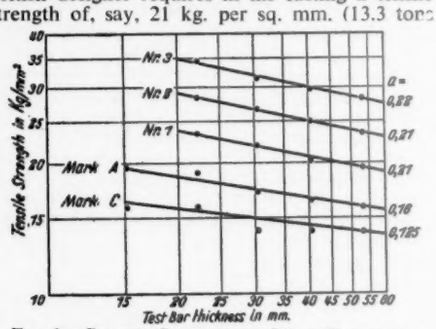


Fig. 3.—British Standards. Wall Thickness Sensitivity.

per sq. in.), he sees that for a casting having a wall thickness of 20 mm., he must use grade No. 1. If, however, the casting has a wall thickness of 50 mm., while a tensile strength of 21 kg. per sq. mm. is required, he already knows from the specification that he must order the higher grade iron No. 2, notwithstanding the fact that the tensile strength is the same.

The Norwegian designer, on the contrary, will order Sj 22.91 in both cases, irrespective of the wall thickness. Of course, in the case of a casting having a wall thickness of 50 mm., the Norwegian foundry, just like the British foundry, will use an iron of a higher grade than in the case of the casting having a wall thickness of 20 mm. The Norwegian designer, however, will only be aware of this if he is conversant with the meaning of wall thickness sensitivity and its consequences for the foundry, which is not always the case, at least not in Germany. Both methods have their advantages and disadvantages.

The British method makes it clear to the designer, through the actual specification, that the same tensile strength in the casting may signify different degrees of difficulty for the foundryman, according to the wall thickness of the casting, and that therefore the 100 kg. price of the casting having the same tensile strength in the wall may vary for this reason alone, quite apart from other factors. This is definitely an advantage of the British standard specifications.

Since the Norwegian specification does not possess this classification, and therefore a knowledge of these matters is often possessed only by the foundry, this is a disadvantage of the Norwegian specification. On the other hand, the latter is simpler for the designer, because he is able to tell much more quickly, and generally even knows off hand, what iron he has to order and does not have to refer to the specification beforehand. If he requires a tensile strength of 21 kg. per sq. mm. in the casting, he will order Sj 22.91, irrespective of the wall thickness. This combination of a fundamental characteristic of the iron in the casting with its short reference designation is definitely an advantage of the Norwegian specification and in some instances will obviate confusion. The absence of this advantage in the British standard specifications is, of course, their disadvantage.*

Of the countries dealt with in this Paper, only Holland has followed the British standardisation. The author has subsequently learnt that Sweden, not considered here, has also followed the British method. In Holland, the groups are designated 00, 14, 18 and 22. Group 00 is not subject to testing and has no specified tensile strength. The numbers of the other groups correspond to the tensile strengths in separate or cast-on bars of 30 mm. (1.18 in.) diameter. The guaranteed tensile strengths given in the

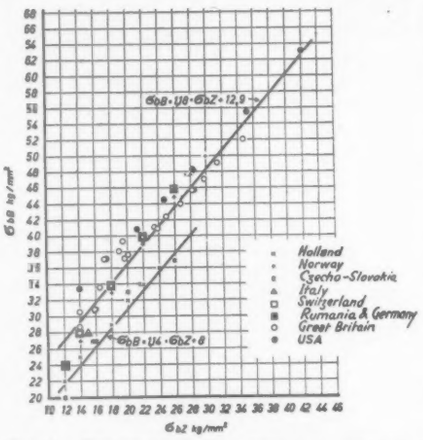


Fig. 4.—Relationship Between σ_{bZ} and σ_{bB} in Various Standard Specifications.

specification for bars of 20 and 40 mm. (0.78 and 1.57 in.) diameter are correspondingly higher or lower. Thus, for instance, it may happen that a cast iron Ge 18 can have a guaranteed minimum tensile strength of 20 to 16 kg. per sq. mm. (12.7 to 10.1 tons per sq. in.). It is therefore possible that the designation does not bear any relationship whatever to the guaranteed value, *although to all appearances that is the case.* If such a method of classification is to be adopted for the standards, the British method of denoting the grades seems to the author to be more satisfactory, because it does not suggest any deceptive relationship between the tensile strength and the abbreviation.

Apart from the three above-mentioned standards, all the others follow the second system of classification, represented in Fig. 2 by the Norwegian standards, and also by the German standards. It may be said that a large number of countries has adopted the German example in drawing up their classifications. Norway, to which reference has already been made, has the grade Sj 30.91 with the tensile strength of 30 kg. per sq. mm. (19.0 tons per sq. in.), which is higher than the highest German grade. Rumania has the same classification as Germany and so has Switzerland, with the exception of class Ge 14.91 and without any obligation for grade Ge 26.91, then comes Poland with the exception of grade Ge 12.91, but in that country only the figures for the transverse tests are standardised. Italy has a very similar classification, *i.e.*, a class G 00 without guarantee, then the classes G 15, G 18, G 22 and G 26 with tensile strengths corresponding to the numbers following the letter, and this also applies to the Czecho-Slovakian system with grades having tensile strengths of 12, 16, 20 and 26 kg. per sq. mm. (7.6; 10.1; 12.7 and 16.5 tons per sq. in). Even Holland has the same classification as Germany for the 30 mm. (1.18 in.) diameter bar, with the exception of grades Ge 12.91 and Ge 26.91. Hungary has no general standard specification for cast iron, but it has one for cast-iron pressure pipes and for pressure pipe castings. The two existing grades have tensile strengths of 14 and 18 kg. per sq. mm. (8.9 and 11.4 tons per sq. in.), respectively, and thus also come within the scope of the German classification.

America follows the German classification, at least as regards the tensile strength. Even though the U.S. grades are quite different from the German grades and from those of the other corresponding European countries, this difference resides mainly in the system of dimensions. There are seven grades between 14.0 and 42.3 kg. per sq. mm. (8.9 and 27 tons per sq. in.) tensile strength, but the details are of little interest here as they have nothing to do with the fundamentals.

In the foregoing, the highest and lowest values for the tensile strength have been given for the lowest and highest grades in the various countries. Standardisation is carried to the highest point in U.S.A., for a tensile strength of 42.3 kg. per sq. mm. (27 tons per sq. in.), then follows Great Britain with 22 and 18 tons per sq. in., according to the wall thickness. Norway comes next with 19 tons per sq. in., and then Rumania, Poland and Czecho-Slovakia with 16.5 tons per sq. in. (Switzerland also, but not compulsory), and finally Holland (and Switzerland, compulsory) with 14 tons per sq. in. The lowest grades in the Norwegian, Rumanian, Swiss and Czecho-Slovakian specifications have a tensile strength of 7.6 tons per sq. in., and in the U.S., British, Dutch (for the 30 mm. (1.18 in.) bar) and Polish specifications, they have a tensile strength of 8.9 tons per sq. in. Italy does not specify any values for the G 00 group. The first grade with specified values for the tensile strength commences at a tensile strength of 9.5 tons per sq. in.

The transverse strengths laid down in the standard specifications of countries other than Germany are not of such great interest from the present point of view, because they bear a certain relationship to the tensile strengths and thus do not contribute anything further to the elucidation of the fundamental principles underlying the specifications.*

It is also unnecessary to discuss at any length the deflections given in the various standard specifications, because the figures given have nothing to do with the essentials of the specifications. In addition, the bars employed in the different countries differ in thickness, and the

* The full advantage of a standard specification with its "classification according to material," like the British specification, is, of course, attained only if the tensile strength figures for the various wall thicknesses in the different grades are selected so that they correspond to the wall thickness sensitivity of actually existing grades of iron, and so that, for example, only five grades of iron suffice. The author does not consider that this has really been attained in the British standard specifications. In Fig. 3 the tensile strengths of the five grades of the British specifications have been plotted as usual in a system of Cartesian co-ordinates with logarithmic scales against the thickness of the test-bars, and the *a* values for the wall thickness sensitivity of the various grades have been calculated from the slope of the lines. It is striking that the exponents for the lower grades are smaller than those for the higher grades. The exponents for the higher grades are of the orders of magnitude previously found for such materials by the author in collaboration with Heller.[2] It is, however, very doubtful whether the exponents for the lower grades A and C are correct, and it must be presumed that more than two alloys are required for grades A and C in order to comply with the specification. This means, of course, that the advantage of this method of standardisation is again partly lost.

* On examining the specifications, a peculiar feature may be observed. Fig. 4 is a graph showing the relationship between tensile strength and transverse strength as laid down in the various standard specifications. In by far the greater number of countries the adopted relationship is one which, considered broadly, is approximately rendered by the upper straight line with the equation :—

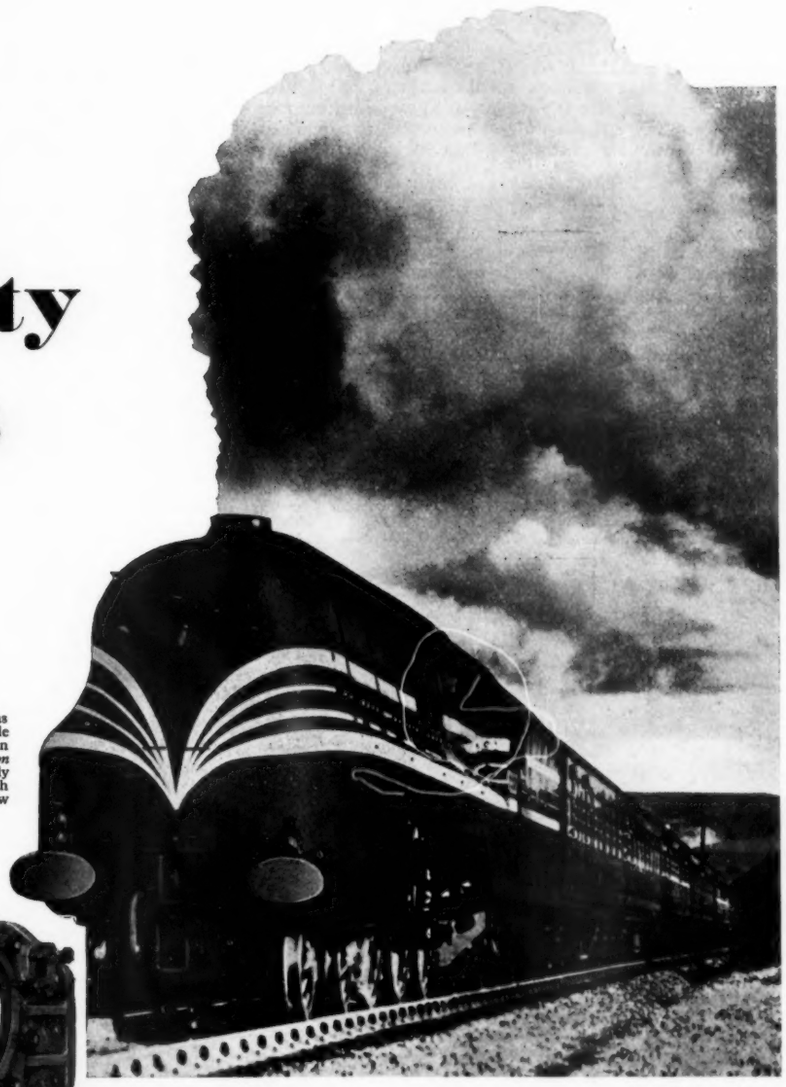
$$\sigma_{bB} = 1.18\sigma_{bZ} - 12.9 \text{ kg. per sq. mm.}$$

where σ_{bB} is the transverse strength and σ_{bZ} is the tensile strength, while Holland and Czecho-Slovakia adopt the relationship in accordance with the lower straight line with the equation

$$\sigma_{bB} = 1.14\,\sigma_{bZ} - 8 \text{ kg. per sq. mm.}$$

This does not, of course, affect the principles on which the standards have been based. A second peculiarity is to be observed in the case of the U.S. specification. In connection with the tensile strength, the effect of wall thickness is ignored, but this is not so with regard to the transverse strength, although the bars for the tensile strength are machined from the bars for the transverse test. The author is quite unaware of the reasons for this.

For Quality Castings



The Coronation Scot (*L.M.S. Photo*)

In locomotive castings such as that shown below, Stanton-Dale Refined Iron was used. Dale Iron was chosen for all the ten *Coronation* class engines and can be confidently used in the manufacture of all high duty castings to rigid and narrow specifications.

STANTON-DALE REFINED PIG IRON

Grade	Silicon. %	Sulphur. %	Phosphorus %	Manganese. %	Total Carbon. %
A	1·9-2·1	0·06	0·7	0·8-1·5	2·6-2·8
B	1·4-1·6	0·07	0·7	0·8-1·5	2·6-2·8
C	0·9-1·1	0·08	0·7	0·8-1·5	2·6-2·8
D	2·4-2·6	0·05	0·5	0·8-1·5	2·6-2·8
E	0·9-1·1	0·08	0·25	0·8-1·5	2·7-2·9
F	1·4-1·6	0·07	0·25	0·8-1·5	2·7-2·9
G	1·9-2·1	0·06	0·25	0·8-1·5	2·7-2·9

In addition to the above standard grades, this iron can be supplied to individual specification.

Produced under the most rigid chemical control, Stanton-Dale is a refined iron of dense, close-grained structure, with a total carbon of 2·6 to 2·9 per cent.

The use of "Dale" iron will give a tensile strength of 16-18 tons per square inch, and it is in wide demand for the production of motor car cylinder blocks, locomotive cylinders, hydraulic and pressure work—in fact for all high duty requirements.

Any analysis can be supplied to meet individual requirements.

The Stanton Ironworks Company Limited, Near Nottingham

The largest producers in Great Britain of foundry pig iron for the free market

conditions under which they are supported during test are also different. According to G. Meyersberg[3] and P. A. Heller and H. Jungbluth,[2] simple mathematical conversion of the values gives deflections which are no longer in agreement with the observed values. This point will therefore not be discussed more fully here.

Testing

The provisions made in the various standard specifications with regard to testing are intended to indicate the manner in which the guaranteed properties are to be proved, only the mechanical properties being considered in the present instance. Such provisions are necessary, because fundamentally there are two different points of view with regard to what actually is to be guaranteed in the specifications. The existence of two points of view is another consequence of the thickness sensitivity of cast iron.

One group of experts supports the view that the laws governing the wall thickness sensitivity of cast iron are quite unknown, or at least are known only imperfectly, and that it is therefore unnecessary to pack the specifications with uncertain knowledge. It would, they say, be better to give a guarantee not of the properties of the casting but of the cast iron quite generally, especially as in any event different strengths are to be expected in the casting on account of the different wall thicknesses. These experts therefore propose to test a separately-cast and accurately defined test-bar, independently of the wall thickness of the casting which is to be made. It is then a matter for the designer to estimate on the basis of his experience the mechanical properties which the casting will presumably have in its different wall thicknesses.

Experts of the second group are of the opinion that it is undoubtedly the purpose of the specification to guarantee the mechanical properties of the casting itself. Obviously, in such a case, the guarantee can relate to only one of the various wall thicknesses of the casting, the "decisive" wall thickness being fixed by the designer or by previous arrangement. The most unambiguous results will, of course, be obtained in the case of this point of view if the test-bars are taken from the casting itself.

In many instances, however, if not in most, this gives rise to so many difficulties that, as a rule, other methods are adopted. One is to cast the test-bars on to the casting, their dimensions being adapted to the decisive wall thickness of the casting. Frequently, this is effected by subdividing the castings into different classes according to their wall thickness, and using for each class a test-bar of dimensions fixed once and for all. In the other method, the test-bars are cast separately but, as in the case of the cast-on bars, their cross-section is adapted to the wall thickness of the casting, the various cross-sections being graded if desired.

This unambiguous system is not always carried into practice as it leads to difficulties. The iron is subjected to a tensile test and also to a transverse test, which will be discussed more fully below. Bars for the transverse test are generally of considerable length, and such bars are therefore rarely cast-on, so that often the bars for the tensile test are cast-on bars having a diameter adapted to the wall thickness, while the bars for the transverse test are cast separately. In the author's opinion, such a provision is meaningless. Finally, provisions are also made to the effect that cast-on test-bars should be adapted to the wall thickness of the casting, but should not have a diameter larger than that laid down in the specification (*e.g.*, 30 mm. (1.18 in.), while the separately-cast transverse test-bars should be of constant dimensions (the German standard specification, for instance, belongs to this group). This also has no real meaning unless the standard specification is at the same time limited to a definite maximum wall thickness (see under the heading "Scope of the Standard Specifications").

Table I presents in simplified and abbreviated form a review of the form of testing as carried out in the various countries. The normal and generally desired method of testing is indicated by crosses, the bracketed crosses indicating the method permitted in isolated cases.

Switzerland alone has adopted the most extreme standpoint of testing the cast iron with separately-cast test-bars of constant dimensions. In that country, therefore, the cast iron *per se* is tested. Rumania has adopted a very similar system, except that the cast-on test-bar is required as a general rule. In these two countries, therefore, it is practically speaking the cast iron itself and not the casting which is tested, although it must be admitted that the Rumanian specification states that the strengths as determined are absolutely applicable only to castings having a wall thickness of 20 to 40 mm. (0.79 to 1.57 in.).

Holland, Norway, Great Britain and U.S.A. employ in all cases test-bars adapted to the wall thickness, separately-cast bars being normally used. Great Britain also accepts cast-on bars on an equal footing, and Holland does so as an exception. The remaining countries belong to the mixed group mentioned above, they adapt the bars for the tensile test to the wall thickness, while the bars for the transverse test are of constant diameter. Finally, Italy and Poland also allow test-bars machined from the casting, in addition to cast-on or separately-cast test-bars.

Despite the varied character of the picture just outlined, all the specifications discussed have one point in common, as is shown in Table I. All the countries specify the separately-cast test-bar, or admit it as equal or, in the case of Rumania, as an exception.

Another important point is whether a tensile test or a transverse test should be made. The advantage of the tensile test is that the test conditions are most clearly defined and the cross-section of the test-bar is subjected to a uniform stress field. Furthermore, it requires very little material. In the case of cast iron, however, it has the disadvantage that it fails to provide any value for the deformation of the iron under stress, because the elastic deformations are too small to be measured without a mirror device, while plastic deformations in the form of an elongation practically never occur. The transverse test, on the other hand, has the disadvantage of providing a composite field of stress under load and is hence not such a clearly-defined test as the tensile test. In addition, it requires much more material. On the other hand it provides, in the form of the deflections, an easily determined value for the deformation of cast iron under load.[4] All the specifications discussed in this Paper provide for both types of test. Norway and Italy lay more emphasis on the transverse test, and Czechoslovakia considers the tensile test to be more important, while the remaining countries treat both tests as equal. As stated above, in the countries which specify tensile test-bars with variable diameter and transverse test-bars with constant diameter, it is the author's opinion that the transverse tests are of little value, because the nature of the structure and hence the strength of tensile test-bars may be quite different from those of transverse test-bars.

A review of the foregoing considerations regarding the standardisation of cast iron in the countries discussed shows that although there are some differences, these do not appear to be insurmountable. Actually, the time is gradually becoming ripe for international standardisation, and the German standard specification, appropriately revised, could provide pioneer service in that work.

TABLE I.—*Precis of Test Conditions Laid Down in Standard Specifications.*

Country.	Nature of test-bar.			Nature of test.		Diameter of bar.	
	Machined from the casting.	Cast-on.	Separately-cast.	Tensile test, (T).	Transverse test, (D).	Adapted to wall thickness.	Constant diameter.
Holland	—	(×) (only T)	× (T from D)	×	×	×	—
Norway	—	—	×	(×)	×	×	—
Czecho-Slovakia	—	× (only T)	×	×	(×)	×	× (onlyD)
Italy	×	× (only T)	× (T from D)	(×)	×	× (but L 30mm)	× (only D)
Poland	×	—	× (T separately or T from D).	×[1]	×	× (only T)	× (only D, machined).
Switzerland ..	—	—	× (generally T from D)	×	×	—	× (T and D)[2]
Rumania ..	—	×	(×)	×[3]	×[3]	—	×
Great Britain ..	—	×	×	×	×	×	—
U.S.A.	—	—	×	×	×	×	—

[1] Values not given in the specifications.
[2] In the case of a considerable wall thickness, from about 50 mm. (2 in.) upward, a thicker bar may be used in place of the 30 mm. (1·8 in.) diameter bar.
[3] Absolute applicability of the specified figures for wall thicknesses between 20 and 40 mm. (0·79 and 1·57 in.)

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[1] "La Fonderie Belge" (1938), pp. 654-694.
[2] "Arch. Eisenhuttenwes.," 8 (1934-35), pp. 75-82; "Techn. Mitt. Krupp," 2 (1934), pp. 106-116.
[3] "Arch. Eisenhuttenwes., 5 (1931-32), pp. 513-517.
[4] See B. G. Meyersberg: "Zur Auswertung des Biegeversuchs bei Gusseisen" (Evaluation of the Transverse Test in Cast Iron), "Kruppsche Monatsh.," 12 (1931), pp. 301-330.

Research in Relation to Steel Metallurgy

(*Concluded from page* 374.)

were permitted to retain their resources and facilities without interruption.

Dr. Hatfield next exhibited a colour film, illustrating operations at the works with which he is associated. Referring to the process of arc melting, the speaker mentioned that, at the present time, they had the finest electric-arc plant in Europe—indeed, he thought, in the world.

A lot had been said about the oxygen content of steel; about a fortnight before, he had made a very large commercial cast of steel for a special purpose, and the oxygen content was only 0.002. He thought that they would agree that that was quite an achievement. No other process lent itself to the production of such pure and clean steel as the electric arc basic-lined furnace. By this method it was possible to produce abnormally clean steel, and its Izod-impact value was of the order of 20 ft.-lbs. superior to steel made by any other process. He showed in the film the casting of the ingots, and called attention to the refractory-lined feeder head.

Following the exhibition of the film, Dr. Hatfield showed a number of slides, many of which illustrated work in the Brown-Firth Research Laboratories.

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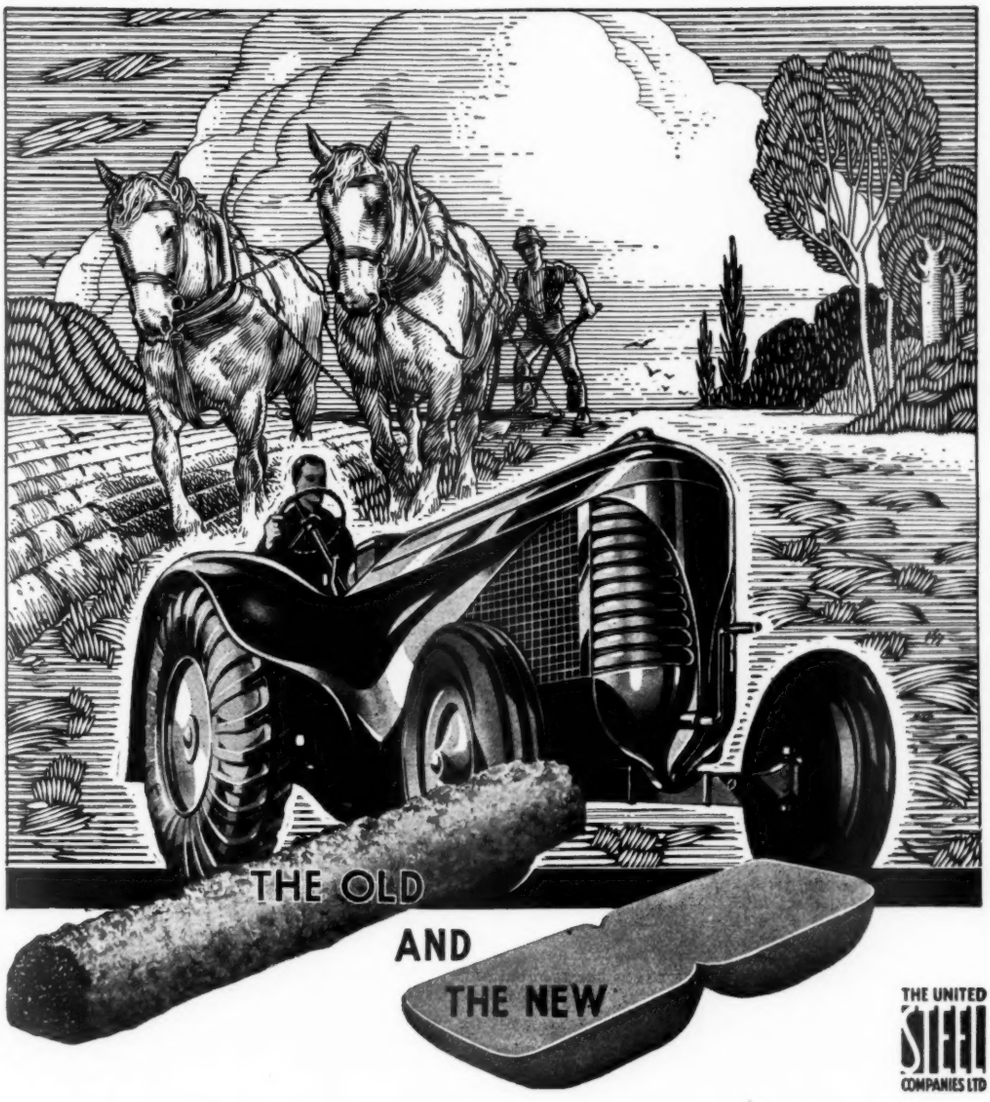

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The Week's News in Brief

Trade Talk

KEIGHLEY ASSOCIATION OF ENGINEERS are to hold a dinner, whist drive and dance at the Victoria Hotel, Keighley, to-morrow (Friday) evening.

THE UNITED STATES STEEL PRODUCTS COMPANY announces a change of name to the United States Steel Export Company, effective November 1.

KENNETH HILL & COMPANY, LIMITED, inform us that their offices are being transferred from St. Stephen's House, Westminster, London, S.W.1, to Blastclean Works, Works Road, Letchworth, Herts. The telephone number is Letchworth 956.

ABOUT 2,000 WORKERS employed in the Scottish factories of the British Aluminium Company, Limited, are to have their pay increased as a result of negotiations completed on November 18 between the firm, the National Union of General and Municipal Workers, and the Transport and General Workers' Union.

DURING THE NEXT three months it may be necessary to adjust the office hours of the Institute of British Foundrymen in the late afternoon, on account of the black-out, particularly during foggy weather. Those who telephone the general office in Manchester and fail to get a reply are requested to ring the Secretary at his residence, 21, Beresford Road, Stretford, Manchester; telephone number, Longford 1053.

THE Institution of Engineers and Shipbuilders in Scotland announce that gold medals have been awarded for the following Papers read during the session 1938-39:—"Marine Propeller Blade Vibration," by J. F. C. Conn; "Statistical and Experimental Investigations on the Singing Propeller Problem," by Dr. J. F. Shannon and Dr. R. N. Arnold. A premium of books has also been awarded for the Paper on "Steam Drifters: Tank and Sea Tests," by J. Edward and F. H. Todd.

THE ANNUAL MEETING of the Meehanite Research Institute of America, Inc., was held in Detroit, Michigan, recently. The officers, who were re-elected, include Mr. O. Smalley, President of the Meehanite Metal Corporation, Pittsburgh, Pa., as President; Mr. H. B. Hanley, foundry manager, American Laundry Machinery Company, Rochester, N.Y., as Vice-President, and Mr. F. M. Robbins, President, Ross-Meehan Foundries, Chattanooga, Tenn., as secretary-treasurer. For the first time this year an entire afternoon session was devoted to the discussion of selling, advertising and sales promotion. In view of existing industrial conditions it was decided that the plans for the forthcoming year would include extended advertising and promotional activities. More than fifty Papers describing the results of research in the metallurgy of Meehanite and foundry technique were presented to the 93 representatives of Meehanite manufacturers in the United States and Canada.

THE Council of the London Chamber of Commerce has adopted the following resolution, which has been transmitted to the Government: "That the Council of the London Chamber of Commerce, recognising, as it does, that a measure of Government control affecting industry and commerce is necessary during war, urges upon His Majesty's Government that such controls should be imposed only where it can be shown that the object to be attained cannot be achieved in a less disturbing way; that the object is itself of such importance in the national interest as to outweigh the great disadvantages involved in disrupting existing manufacturing and distributing machinery; and further that before coming to a conclusion under either heading, the Government should consult with representative trade organisations. Where, however, control can be shown to be essential, this Council urges His Majesty's Government that the democratic method should be followed of consulting the trade, through its appropriate trade organisation, to ensure that the man selected from a trade to control that trade shall be acceptable to it, instead of being imposed upon it from without."

A NEW company, Tungsten Proprietary, Limited, is now being organised for the production of tungsten oxide and tungsten powder from wolframite and scheelite mines in North Queensland. An entirely new process is to be used in refining the ore, and is claimed to be more economical than processes now employed in Germany, Britain, and the United States. By-products of the process will be small quantities of bismuth, arsenic, and tin. The company has made plans for the construction of a plant in Sydney, all equipment for which is to be of Australian manufacture. Production was expected to begin early this month. At present only three companies in Australia are mining tungsten ores. One is in Tasmania, another is at Mount Charlsted, in New South Wales, and the third is the Ironclad Wolfram Proprietary, Limited, in North Queensland. A number of individual miners operate in scattered localities, when the market price is at least £A300 per long ton. The deposit in Queensland is halfway between the southernmost shore of the Gulf of Carpentaria and Cairns, and lies in a flat lode formation under an area covering about 8 sq. miles, with an average thickness estimated at 2 ft. 9 in.

Personal

MR. WALTER M'FARLANE, who has just completed over 46 years' service with Glenfield & Kennedy, Limited, Kilmarnock, where he has been employed in the drawing office, has been presented with a wallet of notes.

COUNCILLOR N. S. KEDDIE, the new Dean of Guild at Auchtermuchty, is a traveller with John White & Son, weighing machinists and ironfounders, of Auchtermuchty. He has been a member of the Town Council for 7 years.

MR. L. F. WRIGHT, director and associated works manager of the Ayresome Ironworks of Gjers, Mills & Company, Limited, of Middlesbrough, was installed on Saturday last as President of the Cleveland Institution of Engineers in succesion to Mr. A. Scholes.

MR. WILFRID AYRE, chairman and managing director of the Burntisland Shipbuilding Company, Limited, and Mr. Alexander Sutherland, secretary of the local works of the British Aluminium Company, Limited, have been made Justices of the Peace for Fife.

PROF. C. E. MARTINEAU AND MR. J. N. ATTHILL, who feel that their state of health will not permit them to carry on their duties under present conditions, have resigned from the board of W. & T. Avery, Limited. The Earl of Dudley and Mr. Douglas W. Turner have been elected directors to fill the vacancies. Mr. Walford H. Turner has been appointed deputy-chairman.

Obituary

MR. A. A. WARDROPPE, cashier and secretary for 20 years with J. L. Thompson & Sons, shipbuilders, of Sunderland, has died, aged 66. He had been with the firm for 50 years.

THE DEATH has occurred of Mr. Herbert Bowman Greveson, of Barnard Castle, manager of Lackenby Ironworks, Grange Town, and manager for 25 years of the L.N.E.R. Hulands Quarry, Bowes.

MR. MURRY GUGGENHEIM has died in New York at the age of 81. He assisted his father and brothers to found the firm of Guggenheim Bros. and to develop large interests in copper smelting and refining.

MR. JOHN TOY, who died at Helston, Cornwall, last Thursday, after a short illness, at the age of 82, was for many years the proprietor of a foundry in the town. The business was only recently converted into a company under the title of Toy & Company.

MR. BERNARD HOLLAND, for many years a well-known figure in the iron and steel trade, died on Monday, November 20. Mr. Holland, who was about 65 years of age, was the son of the late Mr. C. B. Holland, for many years managing director of the Ebbw Vale Steel, Iron & Coal Company. After serving his apprenticeship and gaining practical and commercial experience at various works, he became commercial manager of the engineering department of the Lilleshall Company, Shifnal, Salop. He left the Lilleshall Company to start his own business in London as an engineer's agent, which he had since carried on under the title of Bernard Holland & Company. He represented a number of firms and travelled extensively for them in South Africa, South America and other countries. Mr. Holland was a member of the Iron and Steel Institute and for many years was on the board of the Wolverhampton Steel & Iron Company, Limited.

Contracts Open

Cork, December 6—Iron, steel, non-ferrous metals, castings, etc., for six months, for the Harbour Commissioners. The Engineer's Department, Harbour Office, Cork.

Cairo, December 20—Cast-iron pipes, bends, etc., for the Director-General, Main Drainage Department, No. 4, Sharia El-Antikkhana. The Inspecting Engineer to the Egyptian Government, 41, Tothill Street, London, S.W.1.

Huddersfield, December 18—Cast-iron pipes from 2 in. internal dia. to 12 in. internal dia., also for branches, bends, taper pipes, plug pipes, blank flanges, etc., for the year 1940, for the Town Council. Mr. J. P. Beveridge, waterworks manager, 24, Ramsden Street, Huddersfield.

Salisbury, December 11—Provision and laying of about 1,200 yds. of 4-in. spun-iron mains, for the Salisbury and Wilton Rural District Council. Mr. W. H. Bateman, consulting engineer, Batheaston, Bath. (Fee £1 1s., returnable.)

New Companies

Hughes-Green Engineering Company, Limited—Capital, £4,750. Manufacturers of rotary and other pumps, etc. Subscriber: J. C. C. Green, School House, Dyrham, near Chippenham, Wilts.

John Smith & Son (Alloys), Limited, 1, Broad Street Place, London, E.C.2—Capital, £1,000. Engineers, brass, iron and general founders, etc. Director: L. B. Smith.

Company Meeting

Crabtree Electrical Industries, Limited

Presiding at the annual meeting of Crabtree Electrical Industries, Limited, MR. H. F. MCLOUGHLIN said that the large extension to the grey iron foundry which was under consideration a year ago was now well under way, and, in addition, the inclusion of a non-ferrous section would prove of considerable utility in widening their range of manufacturing facilities. During the past year, considering the restrictive measures in force, their export trade had shown satisfactory expansion. The research and designs sections of their works continued to develop new products with the object of further expanding their activities. All manufacturing departments had continued to work at maximum capacity; a larger value of orders was in hand than ever before.

Company Reports

W. & T. Avery, Limited—Interim dividend of 5 per cent.

Qualcast, Limited—Profit for year to June 30 last, £97,553; brought in, £39,813; bonus to employees, £10,141; expenditure on A.R.P., £1,494; patents written off, £462; income tax and N.D.C., £26,359; preference dividend, £3,915; interim ordinary dividend of 10 per cent., £10,875; final dividend of 10 per cent., plus a cash bonus of 10 per cent., £19,706; to general reserve, £7,750; to taxation reserve, £20,000; carried forward, £33,549.

John Williams & Sons (Cardiff), Limited—Profit for the year ending September 30, after providing for income tax, N.D.C., bad debts, and general depreciation, £16,410; brought in, £8,780; preference dividend of 5 per cent., tax free, £1,500; final dividend on the ordinary shares of 5 per cent., tax free, making 10 per cent., tax free, for the year, £3,800; bonus to staff, £1,250; depreciation, £2,000; depreciation of War Loan, £1,250; pension fund, £2,000; carried forward, £9,591.

Forthcoming Events

Institute of British Foundrymen

DECEMBER 9.

East Midlands Branch:—"More about Synthetic Sands." Paper by A. Tipper, at Technical College, Derby, at 2.30 p.m.

Lancashire Branch:—Joint meeting with Manchester Association of Engineers. "Some Selections from My Book," by E. Longden, at Engineers' Club, Manchester, at 3 p.m.

Lincolnshire Section:—"Melting Furnaces," Paper by S. E. Dawson, at Technical College, Lincoln, at 3 p.m.

Scottish Branch:—"Time and Motion Study in the Foundry," Paper by C. D. Pollard, at Royal Technical College, Glasgow, at 3.30 p.m.

West Riding of Yorkshire Branch:—Discussion on Foundry Problems, at Technical College, Bradford, at 6.30 p.m.

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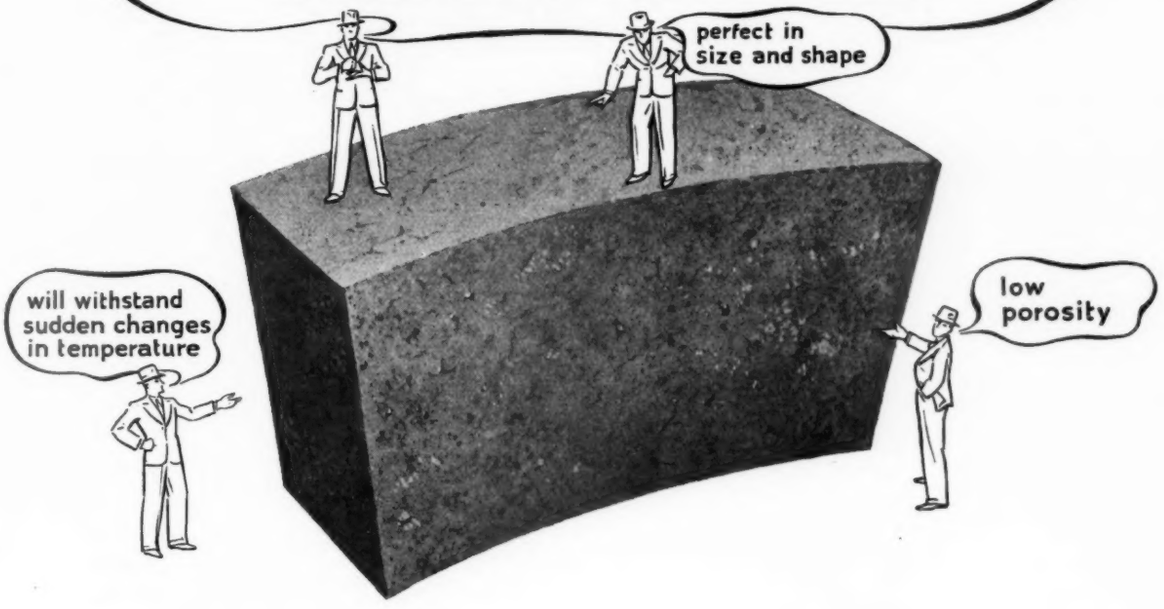

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Raw Material Markets

The Government's system of control of the iron and steel industries is undoubtedly having results advantageous both to producers and consumers. Available supplies are directed to the right channels, thus avoiding undue shortage among works requiring supplies for important national work, while there can be no complaint at the fact that consumers with stocks already in hand are barred from adding to their reserves until their position warrants the allocation of further material. The industry is somewhat concerned at the state of the export trade, which has fallen away to a considerable extent since the outbreak of hostilities, but the position is certainly better than many could have foreshadowed and deliveries to overseas buyers are likely to improve steadily now that the home market has been put on a controlled basis. In reply to a question in the House of Commons last week, the Minister of Supply stated, in effect, that his Department intended to give the export market every attention and licences would be made available at all times when their issue was in the national interest.

Pig-Iron

MIDDLESBROUGH—There is now a pronounced shortage of Cleveland foundry iron, and consumers are buying their needs in the Midlands. Producers are engaged on the production of other descriptions of iron. Users are obtaining licences necessary for them to procure their supplies without undue delay, but permission is only given to buy material required for immediate use and the building up of reserves is prohibited. There are certain consumers still in possession of quite large tonnages of iron bought some time before the institution of the Control measures, and these concerns are not allowed to take up further supplies.

It is generally considered that the increase of 9s. per ton in the price of hematite does not adequately cover the increased costs of production, and that a further rise will be made in prices before long. Production costs are likely to go up still further, as ironworkers are now urging their employers to concede an advance in wages, owing to the rising costs of living. Consumption of hematite continues to expand, but most consumers are adequately covered.

LANCASHIRE—The distribution of supplies is being closely regulated in this area. There is a strong demand from heavy electrical engineers and machine-tool makers, but their orders are generally being met without delay, and these concerns are in a position to carry out their orders satisfactorily. There is only a moderate call for supplies from textile-machinery makers, which is perhaps somewhat surprising, in view of the active state of the textile industry at the present time. Light-castings and jobbing founders, too, would welcome additional business, but there is a gradual improvement among these sections. There is a steady demand for hematite.

MIDLANDS—The addition of Government orders to light-castings makers' books has resulted in a certain improvement in this section, but very few concerns are yet able to find sufficient work to enable them to work to capacity. On the other hand, works producing heavy castings are very actively engaged. Machine tools, aeroplane engines, and other products of works in the Midlands are in heavy request and full-time outputs are assured over a long period. The demands of these concerns, however, are being met in a satisfactory manner. An increase in the production of high-phosphorus iron is needed, and it is expected that this will mature in the near future. Low-phosphorus iron is generally available to meet all inquiries, but larger tonnages would readily be disposed of. There is an adequate supply of hematite iron.

SCOTLAND—There are few complaints regarding deliveries of pig-iron, and the system whereby supplies are rationed according to the needs of consumers appears to be working quite satisfactorily. Fourteen furnaces continue to be employed on the production of Scotch foundry iron. The loss of orders for house-building purposes continues to restrict activity among light-castings foundries, but hopes are entertained of an increase in work of a national character, although not much of this has yet come to hand. The demand for iron for steel-making is maintained at a high level.

Coke

The price of foundry coke, which now stands at 50s. 6d. per ton, delivered Birmingham and Black Country stations, is subject to fluctuation according to the requirements of the Control authorities, but producers have recently intimated that they are willing to sell up to the end of the first half of next year at this figure. There has been a ready response and consumers have welcomed the opportunity to accumulate stocks as a precautionary measure. Supplies of coke are satisfactory and deliveries are being made according to contracts.

Steel

There is much conjecture in the steel market regarding the possibility of a further advance in prices. An agreement reached between producers and employees a short time ago stipulated a rise of 10 per cent. in workers' wages, and this, together with the rising costs of raw materials, represents a considerable burden on makers and may eventually have to be met with the assistance of steel consumers. The demand for all descriptions of steel continues to be very strong and insistent calls for supplies are arriving at the steelworks, which are operating around capacity levels. The bulk of current business is, of course, connected with defence projects, but makers hope eventually to cope more fully with the requirements of ordinary domestic users and also the export trade.

Scrap

The demand for scrap, especially from steel-producing centres, continues to be very substantial, but every effort is being made to increase available supplies and with encouraging results. Not only is the campaign of the Federation for the extraction of unwanted scrap at home going ahead in all earnestness, but there have been further purchases from abroad, thus relieving the position to a considerable extent. The prices of scrap for the manufacture of refined pig-iron, scheduled in the Control of Iron and Steel (No. 5) (Scrap) Order, 1939, are given in the table on this page.

Metals

Important matters affecting the non-ferrous metal trade were discussed when a deputation from the London Metal Exchange called on Mr. Leslie Burgin, Minister of Supply, on Friday. The official statement issued after the meeting did not divulge the exact nature of the discussion, but the deputation were asked to submit definite proposals which the Minister promised to consider carefully. Mr. Burgin was unable to see how the Exchange could fulfil its normal function in wartime, although he stated that it was the Government's hope and intention that it would resume its position as the centre of the world's metal trade at the earliest possible moment. Meanwhile, the Government was the sole importer of metals and would continue to sell only to consumers, as it must direct and control the destination of every available ton of metal. Apart from proposals which would facilitate the reopening of the London Metal Exchange, it is understood that other problems arising out of wartime regulation of metals were also discussed, including dealers' commissions, the constitution of the Non-Ferrous Metals Control, and the relations between the Control and dealers. It is believed that the Ministry has given an undertaking that dealers will be assured of commissions from their normal business as merchants on consumers' behalf.

A Press statement issued recently by Col. J. J. Llewellin, Parliamentary Secretary to the Ministry of Supply, pointed out that the Government was not particularly concerned about the supply position of non-ferrous metals. The main tightness was in aluminium, the use of which for industrial consumption goods had had to be stopped for the time being.

The Non-Ferrous Metal Control has advised the Metal Exchange that in connection with the Exchange clearing on October 31 for settling outstanding contracts in copper, lead and spelter, the Ministry of Supply is prepared to deliver standard copper to its members, whose clients intimated their desire to take physical delivery of purchases made on the Exchange before September 1.

The Minister of Supply has made the Control of Aluminium (No. 4) Order, 1939, revoking the Control of Aluminium (No. 3) Order, but repeating the main provisions of that Order—*e.g.*, a licence is required for the purchase, sale or use of unwrought aluminium or aluminium alloys. Under the new Order, however, the Ministry of Supply becomes the sole seller of virgin aluminium. No maximum price is, therefore, necessary in the Order, but the Ministry have decided to sell aluminium in notch bar or ingot form until further notice at £110 per ton delivered into consumers' works with extras for other forms and purities. The maximum prices previously in force for aluminium alloys, virgin or secondary, and for scrap have been withdrawn and no maximum prices are scheduled in the new Order. It is anticipated that they will find a reasonable level by reference to the new virgin ingot price. The price situation of these materials will, however, be closely watched over. Powers are taken to impose maximum prices at any time by Direction.

Maximum Prices per Ton for Scrap Iron and Steel for Use in the Manufacture of Refined Pig-iron.

Specifications.	For consumers in			
	Northumberland, Co. Durham and Yorkshire.	Cumberland and North Lancashire.	North Staffordshire, Shropshire.	South Staffordshire, Worcestershire.
	s. d.	s. d.	s. d.	s. d.
1.—Short heavy steel scrap, not less than ½-in. thick	66 0	68 3	63 6	63 6
2.—Hematite ingot-mould scrap, in cupola sizes	100 0	—	100 0	—
3.—Heavy machinery cast-iron scrap, in cupola sizes	80 6	77 3	81 0	81 0
4.—Ordinary heavy cast-iron scrap, in cupola sizes	78 0	72 3	76 3	76 3
5.—Medium cast-iron scrap, consisting of gas-stove plate, wringers and similar, in cupola sizes	68 3	63 6	—	—
6.—Light cast-iron scrap, including bedstead cast iron, in cupola sizes	63 3	—	—	64 0
7.—Hydraulically-compressed new steel and heavy faggotted steel	60 0	—	—	—
8.—Heavy steel shovellable turnings	45 6	46 6	—	—
9.—Wire rope, in coils or cut lengths, to works' specification	55 0	—	—	—
10.—Cast-iron borings	40 0	45 0	—	—
11.—Cast-iron borings, not exceeding 0·5 per cent. P	45 0	—	—	—
12.—Burnt cast-iron scrap, in handy pieces	53 9	51 3	—	53 9
13.—Burnt cast-iron firebars	56 3	—	—	—
14.—Compressed destructor scrap	36 9	31 9	34 3	29 3